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THE STUDENT'S HANDBOOK OF

FORENSIC MEDICINE

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PUBLIC HEALTH.

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THE STUDENT'S HANDBOOK

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FORENSIC MEDICINE

AND

PUBLIC HEALTH

BY H. AUBREY HUSBAND, M.B., C.M.

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LATE LECTURER ON MEDICAL JURISPRUDENCE AND PUBLIC HEALTH IN THE EXTRA-ACADEMICAL SCHOOL, EDINBURGH.

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'Analysis of Foods and Drugs,' 'Sanitary Law,' etc.

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PREFACE.

★

THE present Edition has been carefully revised, and much new matter has been added. The section on Optical Phenomena has been increased. The Author hopes that the addition of the diagrams and other illustrations will make the book still more useful, and that it will receive the same meed of favour in the future that it has had in the past.

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FORENSIC MEDICINE.

INTRODUCTION.

TO that branch of medical knowledge which is engaged in the solution of every question connected with the conservation of the species and the administration of justice the term Forensic or Legal Medicine has been applied. It also forms the Medical Jurisprudence of some writers. We find traces of this science in the Jewish law; among the Egyptians, according to Plutarch; and even among the Romans, as early as the times of Numa Pompilius. Among German writers the term State Medicine includes both Medical Jurisprudence and Medical Police, Public Health, or Sanitary Science.

In order to be as concise and plain as possible, it will be necessary to discuss some matters of general application before considering those which have a more special interest. The former will therefore be now considered.

CRIMINAL PROCEDURE.

In England and in Ireland, in criminal cases, a witness is examined, in the first instance, *vivâ voce*, before a magistrate or the coroner of the district on oath, and his answers carefully taken down. These *depositions*, as they are called, form the basis of the trial.

In England, if committed for trial by the magistrate or coroner, the accused may be tried before any of the following Courts :—

Quarter-Sessions.—These are presided over by two or more Justices of the Peace, are held once in every quarter of the year, and take cognisance of smaller felonies and misdemeanours—*i.e.*, offences connected with game, highways, ale-houses, bastard children, settlement and provisions for the poor, servants' wages, and apprentices.

Assizes.—These are the Courts of Oyer and Terminer, and are held at least twice a year in every county in the kingdom. Oyer and Terminer give the Judges authority to hear and determine all treasons, felonies, and misdemeanours committed within the county. The Judges have also authority, under "commission of gaol delivery," to try and deliver every prisoner in the gaol when they arrive in the circuit town.

The Central Criminal Court.—This Court was instituted by an Act of William the Fourth (4 and 5 Will. IV., c. 36), and includes within its jurisdiction the Metropolis, Middlesex, and suburban parts of Essex, Kent, and Surrey. The Judges or Commissioners include the Lord Mayor, Lord Chancellor, past and present, the Judges of the High Court of Justice, Aldermen, Recorder, Common Sergeant of London, Judge of the City of London Court, and such others as the Crown shall appoint. The Court meets in London twelve times in the year. This Court may try all crimes, and cases may be sent from other parts of the country—*e.g.*, Palmer was tried before it.

THE CORONER'S COURT.

The office of coroner is mentioned in a charter, 925. Coroners were formerly chosen for life by the freeholders of the district, but their election is now in the hands of the County Councils. Their duties were first clearly pointed out by the Act (4 Edw. I., 1275).

It is the duty of every coroner, on due notice being given him, to inquire into the cause of any unnatural death taking place in his district *super visum corporis* only; and he has the power, within a convenient time after the death, to order a dead body to be disinterred in order to view it, the *view* being *absolutely* necessary to give jurisdiction to him. The coroner has also power to require the attendance of such witnesses as he may deem necessary for the investigation of the case, all of whom must be examined on oath, and have viewed the body ("Wakley *v.* Cooke," 4 Exch. 511); and such witnesses may be bound over to appear at a future trial. He may, if necessary, adjourn his inquiry for further evidence, etc. The Jury cannot consist of less than twelve persons, but in some cases there may be twenty-three Jurors, all of whom must view the body, their finding being equivalent to the finding of a Grand Jury. As the functions of the coroner are to determine the *cause of death*, all cases of homicide have to be dealt with by the magistrates; thus it often happens that the two inquiries are going on at one and the same time, the one to discover the *cause of death*, the other to decide as to the culpability of the accused, and the necessity for a further investigation in a higher Court. In cases where a verdict of manslaughter or murder has been returned against an individual, the coroner may commit him for trial if present, or he may issue a warrant for his apprehension, either to bring the accused before himself or before a magistrate to be so committed. Bail may be admitted by a coroner (under 22 Vict., c. 33,) in a case of *manslaughter*, but if refused, application must be made to the Court of Queen's Bench in term time, or in vacation to a Judge in chambers; in either case a magistrate of the county or jurisdiction in which the prisoner is in custody may be empowered to accept bail. Even where a verdict of murder has been found, the Court, guided not by the finding of the Jury, nor

by the commitment, but by the facts and circumstances of the case as disclosed by the depositions, may exercise its discretion whether the offence amounts to murder or manslaughter, and refuse or accept bail accordingly.

Coroners, by an Act passed in 1843, are allowed to appoint a deputy to act for them in case of illness.

In England, any medical man may, by warrant from the coroner be called upon to make a *post-mortem* examination, and, if necessary, an analysis of the contents of the stomach and bowels, and to give evidence before him, on penalty of a fine for refusal to comply with the order, which fine of £5 can be recovered by the coroner by suing the medical practitioner before the nearest magistrate. A medical man is not entitled to a fee for a *post-mortem* if made without the order of the coroner, and even with an order unless he be duly registered; also, for a *post-mortem* made in an hospital, lunatic asylum, or other public institution endowed or supported by voluntary contributions, no fee is allowable (6 and 7 Geo. IV., c. 89, sec. 5). In the United States, according to Crocker, if the attendance of a coroner cannot be obtained for twelve hours after the discovery of a dead body, a magistrate may hold an inquest, summoning a regularly qualified physician to assist him.

In Scotland the preliminary proceedings differ from those of England. In the former country information is given either by a private individual or by the police to the Procurator-Fiscal, or public prosecutor, whose duty it is to institute inquiries and to satisfy himself that no blame attaches to anybody. But as soon as the case comes within the cognisance of the Procurator-Fiscal, that secrecy which characterises the Scottish criminal procedure comes into full play. All persons likely to give assistance or throw any light on the matter under investigation are examined, or "precognosced," privately and separately, before the resident

Sheriff, but not on oath, unless the veracity of the informant be doubted. From these persons the Crown witnesses are selected, should the case go to trial. The precognitions when completed are submitted to Crown Counsel—the Lord Advocate and his Advocates-Depute, of whom there are four, besides the Solicitor-General, who takes precedence of the others—for their decision. As a rule, the precognitions taken by the Procurator-Fiscal are placed before one of the Advocates-Depute, who makes an "order," subject, of course, to review by the Lord Advocate—(1) that no further inquiry is necessary; (2) to continue the investigations; or (3) direct a prosecution suitable to the circumstances.

For instance, where the direction given is "*Sheriff summarily*," the prisoner is tried in that manner before the local Judge, whose powers of punishment are limited in this event to a sentence of sixty days imprisonment; again, if the case be ordered to "*Sheriff and Jury*," a sentence extending to two years may be imposed by the Sheriff, should a verdict of guilty be brought in by the Jury; and lastly, if the case be marked by the Advocate-Depute "*Indict*," it is tried either at the High or Circuit Courts of Justiciary. The Court of Justiciary has jurisdiction over all crimes committed in Scotland, or at sea, and is the only competent Court in cases of treason, murder, robbery, rape, fire-raising, deforcement of messengers, breach of duty by magistrates, and in all cases in which by Statute a higher punishment than imprisonment is directed to be inflicted.

When the Crown Council have decided to prosecute, a "diligence," under the hand of the Clerk of Justiciary, is sent to the Crown Agent, who causes it to be forwarded to a macer of the High Court of Justiciary. This document authorises the macer to "summon, warn, and charge" the accused "to compear" before the Court, and also to "summon such witnesses as best know the verity of the premises," and whose names have been duly supplied to him. After carrying out

the directions of the "diligence," the macer returns a certified copy of the names of the persons cited to the Crown Agent. The indictment narrates minutely the nature of the crime, the alleged place of committal, specifies all articles to be used in evidence, and contains also a list of the witnesses.

Should the Procurator-Fiscal decide that a *post-mortem* is required, the usual proceeding is to issue a warrant to the medical man first called to see the case, and joining with him the most skilled practitioner available in the neighbourhood. Where the medical man who saw the deceased before death, or was the first to see the body after it, is not one of the official inspectors, he is usually requested to be present to communicate information. The warrant consists of a petition by the Procurator-Fiscal addressed to the local Judge, setting forth the grounds of his application, and craving warrant to the inspectors named to make the necessary examination. This is signed by the Procurator-Fiscal, and countersigned by the Sheriff or local Judge, if granted. The receivers of this document are empowered to take full custody of the body and effects likely to afford evidence, and they should be *careful to carry the warrant with them*, or they may be refused admission till its production, which may result in a great waste of time, and end in a miscarriage of justice. The Procurator-Fiscal may supply to the medical inspectors portions of the precognitions likely to bear on the medical part of the inquiry.

Medical men ought to be on their guard against performing dissections in cases evidently judicial, without previously warning the proper law authorities, or without a warrant; for instances have occurred where, owing to the want of proper support, obstructions were thrown in the way which might have proved fatal to the value of the investigation; and, besides, the premature disclosure of the results of the inspection might frustrate other important steps of the precognition.

The medical men so engaged will, as a rule, find it to their interest to exclude all visitors, whether lay or professional, from the room during the dissection. The regulations issued by the Crown Office, Edinburgh, direct that no one should be allowed to be present at the examination out of mere curiosity, and recommend that any one not engaged in the inspection, but who is in attendance to give information, or for any other purpose, and who may afterwards become a witness, should remain in an adjoining room. The medical inspection often furnishes good tests of the value of other evidence in the case; therefore, it is desirable that the general witnesses should not have an opportunity of knowing what is observed in the dissection of the body. The notes of a case should be made at the time of inspection or immediately afterwards. In the case of *post-mortem* examinations it is better that while one inspector conducts the practical details of the examination, the other should take notes of its successive steps, indicating all the points inquired into, with the observations made, the appearances presented, negative as well as positive, stating simple facts alone, without either generalisations or opinions. These notes should be looked over by both inspectors before the body is sewn up, so that omissions in the notes, or in the inspection itself, may be then supplied.

CITATION OF WITNESSES—SUBPŒNA.

In England, except upon a subpœna, a medical man *is not* bound to attend as a witness at a trial, and then it should be served a reasonable time before the trial, in order that he may make proper arrangements for the carrying on of his business during his absence. In civil cases his reasonable expenses should be tendered to him at the time the subpœna is served, or within a reasonable time of the trial; and he may refuse to give evidence unless his charges are paid, provided his

objection be stated *before he has been sworn.* A witness may be summoned from any part of the United Kingdom.

In the United States, the attendance of a medical man, although compulsory in criminal cases, does not entitle him to any fee, whether cited on either side.

The question has been raised, whether a *scientific witness* was bound to attend when subpœnaed. The law on the point is enveloped in some obscurity; the better course is therefore to attend.

No tender of fees is necessary in criminal cases, "except in the case of witnesses living in one distinct part of the United Kingdom being required to attend subpœnas directing their attendance in another, who are not liable to punishment for disobedience of the process, unless at the time of service a reasonable and sufficient sum of money, to defray their expenses in coming, attending, and returning, have been tendered to them." When summoned to two cases, the one civil, the other criminal, the witness must attend the criminal; or when both cases are the same, the one to which he first received the subpœna—notifying, however, to the counsel engaged on the other case his unavoidable absence, and giving the reasons which prevent his attendance.

In Scotland, witnesses are summoned by a writ or citation, which must be delivered at the residence of the witness a reasonable time before the trial. Delivery to a member of the family, or a servant not within the house, will not do. If access cannot be gained, the copy is fastened to the most patent door of the house. If the witness does not appear, and it be clearly shown that he was duly cited, a warrant for his apprehension may be issued and he becomes liable to be incarcerated till he finds "caution" for his due attendance at the trial. His non-attendance may also, unless good excuse be forthcoming, render him liable to a fine, or *unlaw*, of a hundred merks Scots—about £5.

MEDICAL EVIDENCE GENERALLY.

On the subject of evidence it is necessary to say a few words, for it must be remembered that that which may be held to be evidence in logic may not be so in law. Nothing in law is intuitive—nothing is self-evident ; everything must go through the process of proof by testimony.

Legal evidence is therefore composed of testimony, but all testimony is not necessarily evidence in law. Thus, if a witness declare that he saw a certain act committed, his testimony may be accepted as evidence ; but if he state that his knowledge of a fact is obtained from another person, such information, although it contain an absolutely true description of what actually occurred, will not be received. In this case his testimony is simply hearsay, and as such is not admissible, except in the case of dying declarations, and in one or two other instances which do not, however, concern us.

Medical evidence may be divided under the following heads :—(1) Documentary ; (2) Oral or Parol ; (3) Experimental.

1.—DOCUMENTARY.

Under this head are included Medical Certificates, Written Opinions, and Medical Reports.

The Medical Certificates. — Certificates generally refer to death, to vaccination, to the state of health of an individual, etc. For those which have respect to the health or to the illness of an individual there is no particular legal form as a certificate is merely a simple statement of a fact. The only essential condition is that it contains the exact truth, and any departure from this will entail heavy penalties. The laxity and want of care in giving certificates was sadly exemplified in a recent trial,—Mr Justice Hawkins remarking that he was " determined never to accept a doctor's certificate again unless it is accompanied

with the affidavit of the doctor."—The offending medical man has certainly not added to the credit or honour of his profession. A statement signed by a registered medical practitioner, distinctly describing the condition of A or B, is all that is necessary as far as the law in England is concerned. In Scotland the law is somewhat different, for "A certificate of bad health by a physician or surgeon must bear to be *on soul and conscience*." . . . . "In cases of homicide, and other crimes against the person, medical certificates produced respecting the nature of the injuries must be verified on oath by the medical persons who granted them" ("Dictionary Scot. Law"). In Scotland also, the omission of the words "on soul and conscience" invalidates a certificate, and a juryman suffering from illness has been fined because the words were omitted in the medical certificate on which he claimed exemption.

Certificates of death, of vaccination, and of insanity, can be procured already printed in the forms prescribed by the law.

Written Opinions.—These generally refer to civil questions.

The Medical Report.—A *Report* is a document given in obedience to a demand by the public authorities in Scotland, and has reference chiefly to criminal cases. Medical Reports are sworn to as true by those who draw them up. According to Alison, it is not a sufficient objection that a Medical Report was made up at an interval after the occurrence of the circumstances to which it refers. The same high authority also states that should the writer of a Medical Report die before the trial, his Report may be used in evidence,—this may be doubted.

The necessity for simplicity in the arrangement and in the wording of their Reports cannot be too strongly urged on medical men. "A medical witness will do well to remember, also, that copies of his Report and

depositions, either before a coroner or a magistrate, are usually placed in the hands of counsel as well as of the Court; and that his evidence, as it is given at the trial, is compared word for word with that which has already been put on record." All hearsay statements and irrelevant matter should not be inserted in a Report; and the reporter should be particularly careful not to add any comments to his simple narration of facts. Thus, such expressions as these—"Under circumstances of great suspicion," "That this woman was murdered, and that with extreme ferocity," "That a severe struggle had taken place before death"—were severely commented on by the late Lord Deas in the case of "R. *v.* M'Lachlan." The use of superlatives is also very objectionable, as it partakes somewhat of exaggeration. All technical words or phrases should be as much as possible avoided; and where they are absolutely necessary, they should be briefly explained.

As a case in point, showing the necessity for care in the use of words, I quote the following from a published Paper by the late Sir R. Christison:—"Some years ago on an important trial in the High Court of Justiciary for assault, the public prosecutor attempted to prove that the person assailed had been wounded to the effusion of blood; which is held in law to be an aggravation of guilt in such cases. When the principal medical witness was examined as to the injuries inflicted, he was asked whether any blood had been effused; and he replied that a good deal must have been effused. But he meant that there was effusion of blood under the skin, constituting the contusion he had described; while the counsel and the Court at first received his answer as implying that there had been considerable loss of blood from a wound. The latter view was on the point of passing to the Jury as a fact, when one of the Judges detected the equivoque, and set the matter to rights." *

* "Monthly Journal of Medical Science," 1851.

In Scotland a medical practitioner may be called upon by the authorities to grant reports as to dead bodies, without performing a *post-mortem* examination.

In the first case, where a death has occurred unaccompanied with any suspicious circumstances, or where the evidence of suicide or death from accidental injury is apparent from a simple examination of the body, a certificate "on soul and conscience," stating the probable cause of death, is considered sufficient by the authorities, and a *post-mortem* is dispensed with. It is not necessary that the deceased be seen by the medical practitioner before death, "yet, from the suddenness of the death, the age of the deceased, and the symptoms spoken to by the friends, he may still be enabled, satisfactorily to himself, to certify the cause of death." In England, such a case would be the subject of a coroner's inquest.

In the second case, he may be summoned by a constable to inspect a body found on the public road, or in any other unusual situation. In this case he is called not only to certify the fact, but also the probable *cause* of death. He may, under these circumstances, give a report of the external examination of the body, at the same time suggesting the necessity for further and more careful examination by dissection, etc., and this we consider the proper course for him to take. In England, in this case also, an inquest would be necessary. In all cases medical men will consult their own interests in giving these Reports.

A Medical Report consists of two parts—the *Minute of the Examination*, and the *Reasoned Opinion* on the first portion of the Report. In the case where the Report is made by two or more persons appointed for the purpose, the latter portion is written in the plural, and signed by each of the parties certifying.

The following is an outline of a Medical Report, which may be more or less modified to suit the requirements of the case:—

FORM OF MEDICAL REPORT.

(*Date.*) (*Place of Examination.*)

(*Names of those who can speak to the Identity of the Body.*)

I.—MINUTE OF THE EXAMINATION.

1. External Inspection.

1. General Condition of the Body.—(*a*) *Well or ill nourished.* (*b*) *General Colour.* (*c*) *Marks and scars.* (*d*) *Products of Disease—Ulcers, hernia, etc.* (*e*) *Injuries.*

   Caution—There may be no external marks of injury, and yet death may be due to violence. Extreme difficulty in deciding if injury be inflicted before or after death.

2. Height.—*Determined by measurement.*
3. Age.—*This can only be approximately guessed.*
4. Sex.—*This is, of course, only difficult when putrefaction is far advanced. Hair found only on the* mons veneris *or* pubes *is characteristic of the female, but if it extends upwards on the abdomen, equally so of the male. No sex can be distinguished in the embryo before the third month of intra-uterine life.*
5. Colour of the eyes.—*Difficult of determination.* Why? (*a*) *Disagreement of observers.* (*b*) *Presence of putrefaction.*
6. Colour of the Hair.—*This is necessary, in order to compare hair of deceased with that found on suspected party.*
7. Position of the Tongue.—*Normal or abnormal, injured or uninjured.*
8. Condition and number of the Teeth.—(*a*) *Complete.* (*b*) *Incomplete.* (*c*) *Any peculiarity as regards size or form, in order to compare with mark or bite on suspected party, etc.*
9. Signs of Death.—*Presence or absence of the* rigor mortis *or supervening putrefaction.*
10. Condition and Contents of the Hands and Nails.—(*a*) *In the drowned: weeds, sand, and signs of long immersion.* (*b*) *In those shot: scorching or blackening of the hand from powder, or injury from recoil of the weapon. Is the weapon grasped firmly in the hand? Cadaveric spasm? Cadaveric rigidity?*
11. Condition of the natural openings of the body—Nose, Mouth, etc.—(*a*) *Presence of sand or weeds in mouth of those found in the water.* (*b*) *Presence of marks of corrosive poisons.* (*c*) *Presence or absence of the signs of virginity, or of recent injury about the parts.*
12. Condition of the Neck.—(*a*) *Presence of marks of strangulation.* (*b*) *Condition of the upper cervical vertebræ.* (*b*) *Dangers to be avoided in determining the fracture or dislocation of the cervical vertebræ. Great mobility of neck, sometimes present, not due to injury of the bone.*

2. Internal Inspection.

A.—Cranial Cavity.

1. Condition of the bones of the skull.
2. Condition of the membranes and sinuses of the brain.
3. Condition and appearance of the brain substance.
4. Contents of the lateral ventricles.

B.—Thoracic Cavity.

1. Position of the organs on opening the chest.
2. Condition of the heart, large blood-vessels, and pericardium.
3. Condition of the lungs, larynx, trachea, and gullet.

C.—Abdominal Cavity.

1. Position of the abdominal organs.
2. Healthy or diseased condition of the liver, spleen, stomach, bladder, and kidneys.
3. Contents of the stomach and bladder.—*Should it be necessary to remove the stomach and intestines, a ligature should be placed at the cardiac extremity of the stomach, and another on the sigmoid flexure of the colon, and then a division beyond the ligatures will permit of the entire removal of the bowels.*
4. Condition of the blood-vessels.

II.—THE REASONED OPINION.

In this portion of the Report the inspectors state the nature of the conclusion at which they have arrived, and their reasons.

Recapitulation of the foregoing Rules.—It may be of advantage here to re-state, in a tabular form, a few suggestions as to the composition of the Report:—

1. Let the Report be as short as possible, but state your views with clearness and distinctness. After stating the nature of the disease in any organ, report "all other organs healthy," if they have been found so. To specify some organs, omitting others, may lead to a pressing inquiry from counsel as to the condition of the supra-renal capsules, or some other unimportant organ, and an unfounded doubt cast on the Report of the examiner.

2. Always avoid the use of technical terms as far as possible, so that you may be saved the annoyance of having to explain your meaning in the witness-box.

3. Express all dates and numbers in writing. Measure all marks, and describe their size and appearance in writing. Carefully write all names of persons to whom reference is made. Take accurate notes, and from them compose your Report. Make a list of all articles submitted for inspection and analysis, and label them.

4. State all facts clearly and chronologically. A *fact* is what is known directly and personally to witness, and not what has been repeated by some other person. Do not report hearsay testimony as matters of fact.

5. Every Report should be written under the impression that it may come into Court to be read.
6. Always avoid superlatives and all epithets of feeling or impressions on the mind.
7. Always avoid speculative opinions and reference to moral circumstances, unless specially required to do so.
8. State your conclusions at the end of the Report in as few sentences as possible.
9. Keep a rough draft of all your Reports, for future reference.
10. Transmit Report, signed and dated, without unnecessary delay, to proper authorities.

2—ORAL or PAROL.

A medical man may be called as a *common* witness, or as an *expert* or skilled witness. In the *first* case, he has only to state, as any other witness might do, the facts that have fallen under his observation; in the *second*, he has to interpret the facts he has himself observed, or to give his opinion on facts noticed by others. In stating his opinion, a medical witness must be prepared to back up his opinion by such reasons as may be satisfactory to the understanding of his hearers, "and this is the principal qualification of a medical witness, that he make himself *intelligible to ordinary comprehensions.*" No man is bound to give any testimony by which he may render himself liable to any criminal prosecution. (See the ruling of Bailie J. in the case of Mr George Patmore, tried for the murder of John Scott in a duel.)

At the trial, the witness is first examined by the party who calls him: this is the examination-in-chief. He is then cross-examined by the opposite party; and, lastly, re-examined by the former party, when he is offered the privilege of explaining any discrepancies between his examination-in-chief and cross-examination, but he must not introduce any new matter, for by so doing he renders himself liable to be cross-examined on it.

The Use of Notes.—All notes should contain a plain statement of the facts, and, to render them admissable as evidence, they must be taken *at the time*, and duly attested. From the notes prepared as before mentioned

a witness may refresh his memory, but they are not accepted in its place. A witness may not read his notes as evidence, nor may he refresh his memory by documents not his own and not produced, but he may refresh his memory by looking at a document received from the accused at the time of the offence, and kept by him (Geo. Wilson, jun., Aberdeen, May 1, 1861; 4 Irv. 42).

The Use of Books.—No witness is allowed to quote from books, or to quote the opinion of other medical men on the subject, but he may refer to facts. Dr Littlejohn, in his Papers on Medical Jurisprudence,* gives some useful hints on this subject. It appears that a medical witness, in an unguarded moment, stated that his opinion was corroborated by a distinguished member of the medical profession not engaged on the trial. The Judge informed the witness that it was most irregular to have other medical men present at the dissection than those mentioned in the warrant, and that, if the witness did not feel qualified for conducting such dissections, he had better resign the post of medical inspector.

In England, at the request of both parties, the medical and scientific witnesses may be excluded from the Court, but as a general rule they are allowed to be in Court and hear the whole of the evidence of the case. In Scotland they are always excluded, although, by mutual consent, "experts" may remain to hear the general evidence on which they are to express their opinions, but when an expert is giving his opinion the others must leave the Court. In the latter country also, a medical witness who has been in Court cannot be examined on the facts of the case, but only on matters of opinion. A medical man is, however, sometimes allowed, on a special motion, to remain, although he is to be examined as to facts, and withdrawn when other witnesses are to be examined as to facts to which he is to speak. (See case of E. W. Pritchard, H. C. 1865; 5 Irv. 88.)

* "Edinburgh Medical Journal," February 1876.

In giving evidence the witness should—(1) Speak loudly and distinctly. (2) Answer questions categorically—Yes or no. (3) Never use superlatives. (4) Give answers irrespective of results of trial. (5) Express no opinion as to guilt of prisoner: state facts only. (6) Avoid using technical terms. (7) Avoid long discussions, especially theoretical arguments.

When a quotation is made from a book by the examining counsel, the medical witness, before replying to a question based on it, should see that the quotation has been fairly and fully given, due regard being paid to the context. Neglect of this precaution may lead him into considerable difficulty.

A medical witness should remember that he is not retained for a party, but in the cause of justice. He must, therefore, be candid in his manner and simple in his language. Mr Haslam remarks that, however dexterous a witness may show himself in fencing with the advocate, he should be aware that his evidence ought to impress the Judge, and be convincing to the Jury. Their belief must be the test by which his scientific opinion is to be established. That which may be deemed by the medical evidence clear and unequivocal, may not hit the sense of the gentlemen of the long robe, nor carry conviction to the Jury.

The advice given by Sir W. Blizard may not be out of place here:—"Be the plainest man in the world in a Court of Justice; never harbour a thought that if you do not appear positive, you must appear little and mean for ever after; many old practitioners have erred in this respect. Give your evidence in as concise, plain, and yet clear manner as possible; be intelligent, candid, open, and just, never aiming at appearing unnecessarily scientific. State all the sources by which you have gained your information. If you can, make your evidence a self-evident truth: thus, though the Court may at the time have too good or too mean an opinion

of your judgment, yet they must deem you an honest man. Never, then, be dogmatic, or set yourself up for Judge and Jury; take no side whatever, be impartial, and you will be honest. In Courts of Judicature you will frequently hear the counsellors complain when a surgeon gives his opinion with any of the least kind of doubt, that he does not speak clearly; but if he is loud and positive, if he is technical and dogmatic, then he is allowed to be clear and right. I am sorry to have to observe that this is too frequently the case."

Liability of Medical Men to reveal Professional Secrets.—The question has arisen how far a medical man is bound to reveal the secrets confided to him in his professional capacity as medical attendant. This question was raised by Mr Cæsar Hawkins in the trial of the Duchess of Kingston (11 Harg. St. Tri. 243), before the House of Peers, and decided by Lord Mansfield thus:—"Mr Hawkin's will understand that it is your (the other Peers) judgment and opinion that a surgeon has no privilege, where it is a material question in a civil or criminal course to know whether parties were married or whether a child was born, to say that his introduction to the parties was in the course of his profession, and in that way he came to the knowledge of it. I take it for granted, that if Mr Hawkins understands that, it is a satisfaction to him and a clear justification to all the world. If a surgeon was voluntarily to reveal these secrets, to be sure he would be guilty of a breach of honour, and of great indiscretion; but, to give that information in a Court of Justice, which, by the law of the land, he is bound to do, will never be imputed to him as any indiscretion whatever." This is not the ruling in most Continental countries, where the medical man claims the same privileges of secrecy as the priest in confessional.

3. EXPERIMENTAL.

Under this head will be treated the Examination of the Living and the Dead, Identity, Real and Apparent Death, Cause of Death, Exhumations, and Autopsies.

EXAMINATION OF THE LIVING.

With regard to the identification of the living, the presence of a medical man is seldom required, but there are many occasions when his opinion may be sought. Thus, under the Factory Acts, he may have to examine children about whose age doubts may have arisen. The Table on page 29, giving the periods at which the teeth appear, will assist him. A medical man may also be requested to give an opinion as to the mental soundness or unsoundness of an individual. He may also be consulted in cases where questions have arisen as to the existence and character of certain marks on the body—of deformities, either congenital or produced subsequent to birth, or of doubtful sex. The marks which most frequently give rise to differences of opinion are *nœvi materni*, *scars*, and *tattoo marks*. In cases of doubtful sex, the male organs may resemble the female, the female the male, or they may be blended together in about equal proportions.

The following questions may be put to the medical expert—(1) Do scars ever disappear? (2) Can the age of a scar be definitely stated? (3) Can tattooing, when once present, ever become thoroughly effaced by time.

In reply to the first and second questions, I shall quote the words of the late Professor Casper :—" Consequently the scars occasioned by actual loss of substance or by a wound healed by granulation, never disappear, and are always to be seen upon the body; but the scars of leech bites, or lancet wounds, or of cupping instruments, may disappear after a lapse of time that cannot be more distinctly specified, and may therefore cease to be visible upon the body. It is extremely difficult, or

impossible, to give any certain or positive opinion as to the age of a scar." Devergie states that where the brand of a galley-slave has vanished, it may be recalled by slapping its usual position with the palm of the hand. The scar remains white while the skin round it is reddened. A change of temperature to the part will sometimes cause the reappearance of a vanished scar. Washing may also help to reproduce scars. Cicatrices produced in childhood may grow in length, but not in breadth. The shape of a cicatrix will depend upon the character of the wound which produced it; on the nature of the healing process; on the elasticity or tension of the skin; on the convexity of the part; and on the looseness of the subcutaneous cellular tissue. An incised wound healing by the "first intention" will most probably leave a white linear cicatrix; on the other hand, a wound healing by suppuration will leave a more or less irregular scar. The position of a wound on the body also modifies the subsequent cicatrix; thus a linear cicatrix is produced when the wound is in the long diameter of the limb, a more or less oval one when across the limb. The retraction of the skin in the latter case tends to draw the skin at right angles to the line of incision, thus approximating the extremities of the cut, increasing it in breadth and lessening it in length. Owing to one or more of the above-mentioned conditions the typical cicatrix of an incised wound is elliptical, tending, however, in some cases to assume a circular form. Linear cicatrices are found chiefly between the fingers and toes, and where the cutaneous surfaces are concave. In gunshot wounds the resulting cicatrix is depressed and disc-shaped, and more or less adherent in the centre to the subcutaneous tissues, and if the weapon be fired close to the surface of the body, grains of unburnt powder may be seen in the surrounding skin. Cicatrices from burns are, as a rule, large, irregular, and superficial, and frequently give rise to deformity.

A scar left by caustics is circumscribed, deep and depressed in the centre. Cicatrices in the groins are probably syphilitic; those in the neck and under the jaw, strumous.

Dupuytren and Delpech state that the tissue formed in a cicatrix is never converted into true skin—the *rete mucosum* when once destroyed never being re-formed. This may account for the white colour of ordinary cicatrices, but even to this rule exceptions may be taken, and dark brown patches of pigment have been known to mark the situation of old lacerated wounds. I have seen a well defined dark coloration of the skin continue for three months after the application of a mustard plaster, followed at the time by desquamation.

With regard to tattoo marks, the question of their disappearance gave rise to considerable discussion in the celebrated Tichborne case. On this subject the experiments of Hutin, Tardieu, and Casper appear to point to the fact "*that tattoo marks may become perfectly effaced during life*," but that after death the colouring matter with which the marks were made may be found in the lymphatic glands. This is especially the case when vermillion is used. The most permanent marks are made with Indian ink, powdered charcoal, gunpowder, washing blue or ink, and vermillion. These are given in the order of their permanency. Hutin found that in 506 men who had been formerly tattooed, the marks had disappeared from 47 of the number. But besides the spontaneous disappearance of tattoo marks from the lapse of time, these marks may be artificially removed, and in such a manner as as to prevent the possibility of a definite opinion being given as to their primary character. The presence of a scar in the situation of a well-known tattoo mark is suspicious. Thus, the Claimant had a scar on a part where it was sworn that Arthur Orton had been tattooed. The alternate application of strong acetic

acid, potash, and dilute hydrochloric acid appears to be the means adopted for the removal of tattoo marks. (On this subject see also Tardieu's Paper in the "*Annales d' Hygiène Publique*," Jan. 1855, p. 171, *et seq.*)

The identity of the accused may be further proved by the absence or malformation of the teeth corresponding with a bite on the party assaulted. Or it may be proved that the wound inflicted could only have been made by a left-handed person, or in a manner peculiar to those engaged in the slaughtering of animals—*e.g.*, is the cut from within outwards, as employed by butchers? The correspondence in the size of the foot of the prisoner and the footprints found in the vicinity of the crime are important as evidence. The size of the footprint varies in running, walking, or standing, and this fact should always be borne in mind when an examination is required to be made of the footprints in the neighbourhood of the crime. Photographs may be used as a means of identification.

As a means of disguise the hair may be dyed, or the colour may be changed from dark to light. For darkening the hair, solutions of permanganate of potash, of the acetate of lead or the nitrate of silver, are most frequently employed, a wash containing the sulphide of potassium being used before the application of the lead solution. This removes the grease, and helps the rapid formation of the black sulphide of lead. To detect this fraud, some of the suspected hair should be steeped in dilute nitric acid, and then sulphuretted hydrogen passed through the solution, the result being the formation of the black sulphide of lead. If silver be present, the addition of hydrochloric acid will throw down the insoluble chloride of silver. If careful examination be made of dyed hair, it will be found that the dye is irregularly taken by the hair, and I have not unfrequently seen the hair close to the scalp white, or at least several shades lighter than the rest. The scalp may also be seen more or less discoloured especially

when the nitrate of silver is used and applied by the individual himself.

For lightening the natural colour, solutions of chlorine and of the peroxide of hydrogen, of varying strengths, are used; but it must be remembered that the action of chlorine is by no means uniform. The hair retains the odour of chlorine for some time, even after repeated washing, and is hard stiff, and brittle. Devergie states that he has not succeeded in producing a perfect whitening of the hair in less than from twelve to twenty hours. It must be borne in mind that, under certain circumstances, dark hair may become suddenly white. I have seen large patches of grey hair over the head, the result of repeated attacks of neuralgia.

There is one more question bearing on this subject, viz. :—What amount of light is necessary for the purpose of identification?

In one well authenticated case, a lady was enabled to identify the person of a thief by the light emitted by a momentary flash of lightning; and it also appears probable that the flash of light from a gun or pistol may be of sufficient intensity for the purposes of identification.

Table giving the diagnosis of the several forms of insensibility that may be present in persons found in the streets :—

Opium or Narcotic Poisoning.—Pupils contracted to a pin point; the countenance placid, pale, and ghastly; eyes heavy; lips livid; skin cold, bathed in profuse perspiration. In some cases may be momentarily roused by a sharp question or blow. Odour of opium in the breath.

Apoplexy.—Patient is with difficulty if ever temporarily aroused. Face red and bloated; puffing of the cheeks during respiration. Pupils dilated or irregular. More or less latteral paralysis. Patient short-necked, corpulent, middle or advanced age.

Drunkenness.—Odour of alcohol in the breath—this sign must be received with great caution for alcohol may have just been taken to ward off "queer sensations." Other signs not unlike those of apoplexy.

Syncope.—Face pale; pulse irregular, flickering, sometimes almost imperceptible; coldness of face and extremities; breathing shallow, scarcely perceptible, irregular sighing or gasping.

EPILEPSY.—Unconsciousness profound ; then convulsions, unilateral, limited to side of the face, or head and neck, or to the arm. Face distorted ; bloody froth round mouth ; jaws clenched sometimes on tongue ; eyes wide open, and pupils dilated and insensible to light.

N.B.—Carefully note signs of injury. Could they be caused directly by an assailant or received as the result of a fall.

EXAMINATION OF A PERSON SAID TO HAVE BEEN ASSAULTED.

Carefully examine the bruises, wounds, etc., to see if they could have been inflicted as described. Ask no questions that may suggest an answer. Examine all weapons said to have been used, and hand them over to the police. In all cases where danger to life is imminent, send to the authorities, and take dying declarations, as these may become evidence of vast importance, and, if properly taken, are as valid as if given on oath.

EXAMINATION OF PERSONS FOUND DEAD.

Objects of such Examination.—Under this head the following questions arise : (1) Who is it ? (2) What is the cause of death ? (3) How long has death occurred ?

1. To answer the question, Who is it ?

As an aid to indentification, it is important to remember that certain trades leave marks by which those engaged in them may be indentified.

Thus, in shoemakers there may be more or less depression of the lower portion of the sternum, due to constant pressure of the last against the bone.

Tailors work sitting, with the legs crossed, and the body bent forwards. The body is thus cramped, and the abdomen drawn in, and the thorax projects over it, due to the manner of sitting. They frequently have a soft red tumour on the external malleolus. A like tumour, but not so large, may also be found on the external edge of the foot, and a corn on the little toe.

Photographers have their fingers blackened by nitrate of silver, or stained yellow with bichromate of potash.

Seamstresses have the index finger of the left hand roughened by the constant pricking of the needle.

Copyists have on the little finger of the right hand, near its extremity, a corn, and at the end of the middle finger, a hard groove made by the pen.

Violinists have corns on the tips of the fingers of the left hand.

In smokers of pipes the incisors and canines are more or less worn by the mouthpiece, but sometimes the groove is between the latter and bicuspids. In cigarette smokers, the forefinger and thumb are stained with tobacco juice.

In coachmen, corns may be formed between the thumb and index finger, and between the index and the second finger of the left hand, from the pressure of the reins, and between the thumb and index finger of the right hand, from the pressure of the whip.

In bricklayers, from the constant action of picking up bricks, the flattening of the tip of the thumb and index finger of the left hand is not uncommon.

Plasterers have corns on the external surfaces of the thumb and index finger, due to grasping the "hawk" on which the plaster is placed during their work.

The finger-ends of turners and coppersmiths are also more or less flattened ; in the latter, a deposit of the metal may take place.

An examination of the mouth, for the presence or absence of false teeth, or of any peculiar formation of the jaw, may lead to the identification of the body. In the case of Dr Parkman, the recognition by a dentist, of the false teeth worn by the deceased led to identification of the remains, and also to the discovery of his murderer. The presence of an ununited fracture, as in the case of Livingstone, may lead to the identification of the body. In one case where a man was said to have died from a fracture of the ribs recently caused

by a blow, it was found on examination that the bones were united by a firm callus, clearly showing that the skeleton produced could not be that af the man alleged to have been murdered. *Nœvi materni* and cicatrices, as in the case of the living, may also serve as aids for identification. Singular cases of mistaken identity have been recorded from the extraordinary occurrence of like marks on different individuals. In the case of an infant found dead, it may be necessary to determine whether it was born alive, and also whether it had reached that period when it could maintain an existence apart from its mother. (See "Infanticide.")

2. To ascertain the cause or causes of death.

(1) Position of the body.

(2) Attitude of the body.

(3) Relation to surrounding objects.—Signs of a struggle. Direction of footsteps to or from the body. If in a room: What bottles and other articles of medicine are in the apartment? Examine the nature of the excrementitious matter in the night-vessels.—Suicide? Homicide?

(4) Examine body externally.—Are there any wounds on the body? Are there any signs of vital reaction in the wounds; pus, adhesive lymph, or blood clots? Possibility of apoplexy; conformation of the neck, with respect to its shortness, fulness and thickness. Marks upon the throat or under the ears. State of the linen and clothes of the deceased. Whether torn or in any way disordered. Whether stained with blood. Whether they yield the odour of spirit, sourness, putridity, or that of tobacco. Leave the examination of the back till after the examination of the internal cavities, so that no fluids escape from mouth, etc.

(5) Report of witnesses.—Can the body be identified? Is the body in the same situation and condition as when first discovered? Habits of the deceased. When last

seen, and in whose society? What was his occupation or business? Had he experienced any disappointment or misfortune? Any insurance on his life?

(6) Examine cavities.

In no case should a medical man ever hazard an opinion as to the cause of death. When the body is once placed in the hands of the authorities, a medical man has nothing further to do till he receives the warrant for inspection and examination, without which he should be careful not to touch the body for purposes of internal examination.

3. **To ascertain the time which may have elapsed since death.**—This can scarcely be determined with precision, as so much depends upon the conditions under which the body may have been placed. The subject under consideration is, therefore, beset with difficulties, and its elucidation will require the greatest care on the part of the medical expert. A careful attention, however, to the subjects treated in the following pages will help to clear up many a doubtful point.

COOLING OF THE BODY.

(1) External circumstances.	Covered by bed-clothes, or otherwise unexposed, when cooling will be slower than in cold dry air quickly moving.	
(2) Condition of the body itself.	Slow, if fat.	
(3) Kind of death.	1. Wasting diseases. Quick.	
	2. Suffocation. Slow.	
	3. Cholera, yellow fever, rheumatic fever, and cerebro-spinal meningitis.	Increase of heat after death.

The following circumstances must also be taken into consideration:—(1) Age. (2) Air—(*a*) moving; and (*b*) at rest. (3) Moisture. (4) Warmth. (5) Nature of the supposed cause of death. As affecting cooling

of the body, and promoting the rapid advance of putrefaction. (6) Presence or absence of the *rigor mortis.* Bodies may be preserved for months if exposed to intense cold.

The following TABLE, compiled from the experiments of Devergie, may be of use in aiding the expert to form his opinion, but it must be borne in mind that, from the great difficulties which surround the subject, the statements made are only approximately correct. The Table is divided into four stages or periods, the last being that in which putrefaction commences :—

FIRST.—*From a few minutes to twenty hours after death*—Animal heat more or less present, but seldom continuing longer than ten or twelve hours. Muscles contract on the application of galvanic stimuli, and in the earlier stage to blows.

SECOND.—*From ten hours to three days*—Body quite cold and *rigor mortis* well marked ; muscles do not contract on the application of stimuli. The age, mode of death, and other collateral circumstances must, more or less, be taken into consideration before an opinion can be given.

THIRD.—*From three to eight days*—The body is quite cold, and cadaveric rigidity has passed off. The muscles no longer respond to any galvanic or mechanical stimulus. The stage is modified and somewhat shortened in summer.

FOURTH.—*From six to twelve days*—Commencement of putrefaction. Putrefaction may, however, take place on the first or second day after death ; so that, as before stated, care must be taken before any positive decision can be given.

If only the skeleton remains, the following TABLE may be of use :—

SEX.—The thorax in the female is deeper than in the male, the sternum shorter and more convex, the ensiform cartilage thinner and ossified later in life. The cartilages of the ribs are larger, and the rib smaller than in the male. In the female pelvis the *ilia* are more expanded and horizontal ; the *sacrum* more concave ; the tuberosities of the *ischia* are wider apart and flatter, the *pubis* more shallow ; the cartilage of the *symphysis* broader.

N. B.—The angle formed by the descending *rami* of the *ossa pubis* in the female is more rounded, and the pubic arch wider, than in the male. The diameters of the female pelvis at the brim are—antero-posterior, 4½ ; transverse, 5 ; oblique, 5½ inches. Prior to puberty, the examination of the skeleton affords no evidence of sex.

AGE—Eruption of teeth.

Central incisors,	7	months.	Temporary.
Lateral incisors,	7–10	"	
First molars,	12–14	"	
Canine teeth,	14–20	"	
Second molars,	18–36	"	
First molar,	6	years.	Permanent.
2 middle incisors,	7	"	
2 lateral incisors,	8	"	
First bicuspid,	9	"	
Second bicuspid,	10	"	
Canine,	11–12	"	
Second molar,	12–13	"	
Wisdom teeth,	17–21	"	

Examine lower jaw. Ramus forms an obtuse angle in full-grown fœtus, a right angle in adult life, obtuse in old age from loss of teeth. Ossification of bones. Ossification of the epiphysis of transverse and spinious processes of the vertebræ, hardly commence before 16 years of age. From 20 to 30 two thin circular plates form on body of the vertebræ. Consolidation of the sacrum begins at 18th year, completed at 30th. First and second bones of sternum unite between 25th and 30th, and second and third before 35th. Epiphyses of ribs begin to grow between the 16th and 20th years, completed by the 25th. Epiphysis of clavicle begin to form between the 18th and 20th years.

STATURE.—The bones must be laid out in position, and $1\frac{1}{2}$ to 2 inches allowed for the soft parts.

ANY PECULIARITIES.—False teeth. Malformations, and united or ununited fractures.

N. B.—When only portions of the skeleton are found, no reliable opinion of the height of the individual can be given.

MODES OF SUDDEN DEATH.

SYNCOPE. ASPHYXIA. COMA.

Syncope—from συγκοπτω I *strike down.* Arrest of the action of the heart.

This condition may be brought about by—

1. Deficiency of blood due to hæmorrhage—*death by anœmia.*
2. Effect of certain diseases and poisons—*death by asthenia.*

In the former case the heart ceases to act because it has no blood to propel; in the latter, because its muscular walls are paralysed. In some cases of death by asthenia the nervous system is first affected, and then the heart. Sudden death following strong mental emotion, or a blow on the stomach, is of this kind.

Post-mortem Signs.—The cavities of the heart contain a normal quantity of blood in death by asthenia, but may be almost empty when death is due to anæmia. The blood in asthenic death is simply arrested in its course; blood is, therefore, found in the large veins and in the arteries. The brain and the lungs are not engorged with blood.

Asphyxia—From ἀ priv. et σφυξις, *pulse.* Apnœa is the better term—ἀ priv. et πνεω, *I respire;* but this word is now used by physiologists to denote a cessation of the respiratory movements due to artificially oxygenated blood. Blood in this condition fails to excite the respiratory centre in the medulla, and respiration ceases. To avoid confusion the term asphyxia had better be retained, especially as it is most commonly used and generally understood. Asphyxia, or death from defect in the quality of the blood, is brought about when any impediment is placed on the healthy action of the lungs. Experiment has shown that for a short time after respiration has ceased, the heart still continues to act, and that if the impediment to the proper aëration of the air by the lungs be removed, life may be prolonged. Taking therefore the primary meaning of the terms asphyxia and apnœa into consideration, it may be remarked that the latter precedes the former in point of time—asphyxia marking the period at which the action of the heart ceases, apnœa the cessation of the respiratory functions.

Causes.—1. Certain diseases affecting the lungs—pneumonia, bronchitis, etc. 2. Mechanical obstruction

to respiration — strangulation, drowning, hanging, or long-continued pressure exerted on the walls of the chest.

Post-mortem Signs.—Engorgement of the pulmonary artery, the right cavities of the heart, and *venæ cavæ ;* but on the left side of the heart the cavities, together with the aorta and pulmonary veins, are either empty or contain but little blood. It must be remembered, however, that cases of asphyxia do sometimes occur where the cavities on each side of the heart are *empty, or nearly so.* This is the case in the syncopal asphyxia of some writers. If also the obstruction to respiration be imperfect, the circulation may be continued for some time, congestion of one or more of the internal organs being the result.

Coma.—Death in this case is due to some cerebral mischief.

Cause.—Apoplexy, fracture of the cranial bones, compression or destruction of the brain substance.

Post-mortem Signs.—Congestion of the membranes and substance of the brain, and of the lungs. The cavities of the heart, especially those of the right, contain more or less blood.

SIGNS OF DEATH.

Real or Apparent Death.

It will be unnecessary here to discuss any of the theories put forth with regard to cases of apparent death or prolonged trance, but simply to note in the order of their occurrence the phenomena which attend real death.

REAL DEATH.

1. Entire cessation of respiration and circulation; no sounds heard on auscultation. The absence of the heart sounds is the most important sign of death for

even in the severest forms of syncope the cardiac pulsations as shown by M. Bouchat can with care be heard.

2. The lustre of the eye is lost immediately after death. It has, however, been stated that the iris will respond to the action of atropia and Calabar bean for as long as twenty-four hours after death, and that the action of the latter is always more marked than that of the former. A blackish round or oval stain has been described by M. Larcher on the sclerotic coat on the outer side which he calls *l'imbibition cadavérique du fond de l'œil.* It is probably due to thining of the sclerotic from evaporation, enabling the choroid to be seen through it. The spot precedes rigidity and is a forerunner of putrefaction.

3. The most powerful stimulus applied to the body does not cause any *reaction.* The muscles *may,* however, be made to contract shortly after death by the stimulus of a slight blow, or by galvanism.

4. The surface of the body becomes of an ashy-white colour.

EXCEPTIONS.

(1) Persons of florid complexion retain this for some time after death.

(2) The red or livid edges of ulcers.

(3) Blue, black, or red tattoo marks, if not effaced during life, do not disappear.—Ecchymoses retain the hue they had at the time of death.

(4) An "icteric" coloration existing at death never becomes white. Death from jaundice.

(5) A rosy tint of the skin described by Devergie, on those poisoned by carbonic acid. Dusky red patches in those frozen to death.

5. The temperature of the body at the time of death is retained for some time. Cooling will depend on the medium in which the body is placed, and mere coldness of the body is not a sign of death. Average internal temperature of body during life, 98° to 100° F.

(1) Fat persons retain the heat longer than lean ones ; adults longer than children or old persons. Bodies are cooled by—1. Radiation. 2. Conduction. 3. Convection.

(2) Bodies immersed in water cool more rapidly than in air.—This fact may be of importance in determining survivorship in a case of drowning.

(3) Bodies in bed and covered by the clothes, or in cesspools and in dung-heaps, cool less rapidly than when exposed.

(4) Persons killed by lightning keep longer warm than others (?).

(5) Death by suffocation retards the process of cooling.

(6) The body may be cold externally, but possesses a considerable amount of heat when the internal organs are exposed. Persons who have died of cholera, yellow fever, or suddenly of some acute disease—rheumatism—may retain for some hours a considerable amount of heat. It has even been asserted that in some diseases—cholera—there is an increase of temperature soon after death (Laycock).

(7) Most bodies, under ordinary circumstances, are, as a rule, quite cold in from eight to twelve hours after death.

6. Relaxation, more or less general, of the muscular system takes place. "If the above signs are alone present, death must have taken place in from ten to twelve hours at the longest" (Casper).

7. Want of elasticity in the eyeball. This condition invariably occurs in from twelve to eighteen hours after death.

8. Flattening of the muscles of those parts on which the body rests, due probably to loss of vital turgidity.

9. Hypostasis. Suggillation, or *post-mortem* staining is due to the gravitation of the blood to the most dependent parts of the body. The hypostatic marks begin to form in from eight to twelve hours after death, and increase in size till putrefaction sets in. Hypostasis may be mistaken for an ecchymosis or a bruise, and in the lungs for congestion, inflammation, etc. Errors may also occur with regard to the brain, kidneys, and intestines: in the last, the redness of inflammation is seen all over the parts, whereas the colouration of hypostasis is interrupted, and this is best shown by drawing out the convolutions. The heart is an exception to the rule, but it may contain clots varying in

size and colour, and known as *polypi*. These are *post-mortem* formations. The use of the word suggillation is objectionable, as it has been used in opposite senses by Continental and British authors—some writers restricting the term to ecchymosis proper, others using it as synonymous with cadaveric lividity or external hypostasis.

Cutaneous Hypostasis.

(1) *Meaning of the Expression.*—The gravitation of the blood in the capillaries after death, in obedience to the laws of inert matter.

(2) *On what parts of the body usually seen?*—On the most dependent parts of the body; on the whole of the back of the body, if the body be supine. The patches are irregular and slashed, terminate abruptly, and do not fade gradually into the surrounding colourless skin.

(3) *At what period after death first observed?*—In from eight to twelve hours, gradually extending in size till putrefaction sets in.

(4) *Whether or not affected by death from hæmorrhage?*—Formed after every kind of death, even after death due to hæmorrhage, although the colouration may not be quite so marked.

(5) *With what result of external violence sometimes confounded?*—Liable to be confounded with ecchymosis, the result of injury. Hypostasis must also not be confounded with the livid patches seen on the legs and feet of aged persons and on those who have died from typhus, etc. The livid patches—"frost erythyms,"—seen on those who have died from exposure to cold, must not be mistaken for ecchymosis. The above patches are as frequently on the upper surfaces of the body as on the lower, and are not so extended as cadaveric lividities; the blood, moreover, which gives rise to them is diffused through the areolar tissue, and not incorporated with the true skin.

(6) *How distinguished from this?*—Effused or coagulated blood is found when an incision is made in a *true* ecchymosis, however small, whereas a few bloody points are alone seen on a slight or deep incision into a *post-mortem* stain or true hypostasis. The seat of hypostasis is the superficial layer of the true skin. Hypostases are never raised above the surface, as ecchymoses sometimes are. In describing these two conditions, "ecchymosis" and "hypostasis," it is preferable to describe the former as "discolouration from extravasated blood," and the latter as "lividity after death."

10. Cadaveric rigidity. From the moment of death till the time when putrefaction sets in, the muscular structures of the body may be said to pass through three stages :—

(1) *Muscular Irritability.*—The muscles flaccid, but still possessing the power of contractility on the application of certain stimuli. Parts contracted during the act of dying—cadaveric spasm,—as the muscles of the hand grasping a knife or other weapon, may continue so for some time after death.

(2) *Cadaveric Rigidity.*—A state of rigidity, the power of contractility absent.

(3) *Commencement of Putrefaction and Chemical Change.*—Relaxation again present; all power of contraction lost, not to be regained.

Cadaveric rigidity, or *rigor mortis*, is a purely muscular phenomenon, and is not dependent on the nervous system, as it is not affected by division of the nerves, and is as well marked in paralysed as in non-paralysed limbs. Cadaveric rigidity which occurs early in the heart must not be mistaken for hypertrophy, or its absence for dilatation. In every case the *rigor mortis* precedes putrefaction, and consists in a shortening and thickening of certain muscles, chiefly the flexor and adductor muscles of the extremities, and also the elevators of the lower jaw.

This condition commences in the muscles of the back of the neck and lower jaw, and then passes into the muscles of the face, front of the neck, chest, and upper extremities, and then, last of all, into those of the lower extremities. It, in most cases, passes off in the same order, the body becoming quite flaccid, the *rigor mortis* never returning. These phenomena occur whilst the body is cooling. The muscle becoming rigid is dying, the rigid muscle is dead. The cause of the *rigor mortis* is by no means evident. By some it is held to be due to the coagulation of the albuminous transverse bands seen in all voluntary muscles; by others, to the coagulation of the fibro-albuminous fluid found between the fibres of muscle.

Cadaveric rigidity generally supervenes in from eight to twenty hours after death; but in some cases it comes on earlier, and may continue from four to nine days. After narcotic poisoning, the *rigor mortis* is said either not to occur at all, or to pass off so rapidly as to be entirely absent before the body is inspected. In poisoning by carbonic acid the *rigor mortis* is slight; whilst in cases of strychnia poisoning it soon supervenes, but lasts a *long* time. In infants and young children cadaveric rigidity is feeble, and soon disappears. A low temperature at the time of death favours the duration of *post-mortem* rigidity; and this rigidity is still more marked, if with the low temperature, the person be in a state of intoxication at the time of death. Putrefactive discolouration of the body may co-exist with a prolongation of the *rigor mortis.*

This state—cadaveric rigidity of the muscles—must be distinguished from *muscular spasm* occurring at the moment of death. They may be thus distinguished:—In the former case, if any object be placed in the hand prior to the commencement of the *rigor mortis*, the article can be readily removed, even if the precaution be taken of binding it in the hand prior to the accession of the *rigor mortis.* In the case of *muscular spasm*, the object is found grasped in the hand, and can only with difficulty be removed. The difficulty experienced in removing a pistol or other weapon from the hand, may point to suicide; its easy removal to homicide, the weapon having been placed there after death. A frozen body must be distinguished from one in a state of *rigor mortis.* In the former, the body is stiff and board-like; in the latter, the limbs may be bent, and the stiffness is not so marked.

A body showing the signs of death before mentioned (Nos. 1 to 10), may be held to be that of a person who has been dead from two to three days at the longest (CASPER).

TABLE showing the Principal Points to be noted in the period of accession of Cadaveric Rigidity, and the causes which retard or hasten its appearance, or modify its duration :—

In what does it consist?—In a shortening and thickening of the muscles, particularly the flexors and adductors of the extremities, and elevators of the lower jaw.

Period of Invasion.—Generally in from eight to twenty hours after death. It has been known, however, to supervene within three minutes of death, but it may be delayed for sixteen or seventeen hours.

Period of Duration.— From one to nine days. Three weeks (TAYLOR).

Order in which the Muscles are affected.—Back of neck and lower jaw, muscles of the face, front of the neck, chest, upper extremities and then the lower extremities.

Order in which it Disappears.—Back of neck, lower jaw, etc., following the course of its accession.

Effects of Exposure to Cold.—Prolonged by dry cold air, and by cold water.

Effects of Enfeebling Disease prior to Death.—Rapid in its invasion, and passing off rapidly.

Effect of a Robust Frame at Period of Death.—The accession may be prolonged; but, other things being equal, it is more strongly manifested, and continues longer.

Effects of Violent Exercise prior to Death.—Rapidly supervenes, and rapidly disappears. Soldiers killed at the end of a battle.

Effects of Poison.—Poisons which cause violent contractions for some time prior to death—strychnia, etc.,—influence the rapid invasion of the *rigor mortis*, its short duration, rapidly followed by putrefaction. Where death in poisoning by strychnia is almost instantaneous, with a short convulsive stage, *rigor mortis* comes on *rapidly* and remains a *long* time.

PUTREFACTION.

Internal conditions which modify putrefaction :—

1. Age. 2. Sex. 3. Condition of the Body—*(a) Constitutional peculiarity; (b) State of the body.* 4. Kind of Death—*(a) The result of Disease*; *(b) The result of Poison.*

External conditions which modify putrefaction :—

1. Air. 2. Moisture. 3. Warmth.

INTERNAL CONDITIONS WHICH MODIFY PUTREFACTION.

1. **Age.**—The bodies of young children, other things being equal, are said to putrefy rapidly. It should be remembered, however, that clothing possesses considerable power in retarding putrefaction, and that, in the hurry and anxiety to get rid of the infants, they are oftener exposed naked than clothed, which may, in some measure, account for their more rapid decomposition.

2. **Sex.**—Sex, it would appear, has little or no influence either to retard or hasten putrefaction; but it has been remarked that females dying during or soon after child-birth, irrespectively of the cause of death, do putrefy most rapidly.

3. **Condition of the Body.**

(*a*) *Constitutional Peculiarity.*—It is generally admitted that persons of the same age and sex, dying similar deaths, and subjected to like conditions as to exposure to the air and interment in the same soil, exhibit marked differences as regards the accession and rapidity of putrefaction. The explanation may be difficult, but the fact still remains.

(*b*) *State of the Body*—Fat and flabby corpses putrefy more rapidly than the lean and emaciated. Hence old people, who are generally thin, keep fresh for a comparatively long time. Bodies, also, which are much mutilated rapidly decompose—decomposition setting in first at the parts injured. In examining wounds and bruises said to have been inflicted during life, it is well to remember that the tendency of putrefaction is to make them appear more severe.

4. **Kind of Death.**

(*a*) *Effect of Disease.*—Healthy persons dying suddenly, other things being equal, are said to decompose more slowly than those who have died from exhausting

diseases, as in the case of typhoid, phthisis, and dropsy, following organic disease, or of those diseases attended with more or less putridity of the fluids.

(b) Effects of Poisons.—Putrefaction rapidly supervenes in those who have died suffocated by smoke, by carbonic oxide, and by sulphuretted hydrogen. Narcotic poisoning is stated to accelerate this condition; but poisoning by phosphorous, alcoholic blood poisoning, and in cases of death from sulphuric acid, the putrefactive changes are greatly retarded. The manner in which death takes place from the action of the poison greatly hastens or retards putrefaction. Thus, in the case of poisoning by strychnia, it is found that when death has occurred rapidly, without much muscular exhaustion, putrefaction sets in slowly; but that, when the muscular irritability has been by successive fits greatly exhausted, the contrary is the result. Arsenic, chloride of zinc, and antimony are reputed to possess antiseptic properties.

External Conditions which modify Putrefaction.

1. Air.—Exposure in the open air has a marked effect in promoting putrefaction; but garments fitting close to the body, and thus excluding air, have a contrary effect. Dry air, or air in motion, by assisting evaporation from the corpse, acts as a preservative. The composition of the soil in which the body is placed has also a more or less modifying effect. In light, porous soil, allowing of the free ingress of air, decomposition is more rapid than in close, compact soil, as clay; but in this we have to contend with another agent—moisture—which more or less counteracts the protective virtue of the closer earth.

2. Moisture.—Putrefaction cannot proceed without moisture. The body, however, contains sufficient water to enable this process to commence spontaneously

Organic substances artificially deprived of water do not putrefy. Cold and heat possess marked antiseptic properties—the former by freezing the fluids in the body, the latter by drying them up.

3. **Warmth.**—A temperature between 70° and 100° F. is found most favourable to decomposition. The effect of cold is shown by the fact that a body immersed in water during winter, at a temperature between 36° and 45° F., may be so well preserved as to present, ten or twelve days after death, well marked signs of violence, which would in summer have been utterly obliterated in five or seven days. The preservative influence of cold water will, however, depend greatly on the depth at which the body has been submerged. Bodies so submerged, and then exposed to the air, putrefy with such rapidity that exposure for one day is said to work a greater change than three or four days' longer retention of the body in the water. As an instance of the preservative power of cold, may be mentioned the mammoth found in Siberia embedded in a block of ice.

THE PHENOMENA OF PUTRESCENCE IN THEIR CHRONOLOGICAL ORDER.

1.—EXTERNAL.

One to Three Days.—Greenish colouration of the abdominal walls. Odour of putrescence is gradually developed, and, concurrently with this, the eyeball becomes soft and yielding to pressure.

Three to Five Days.—The green colour, of a deeper shade, has now passed over the abdomen, extending also to the genital organs. Patches of this green colouration also make their appearance somewhat irregularly on other parts of the body, such as the neck, back, chest, and lower extremities. A dark-reddish frothy fluid about this time wells up from the mouth.

Eight to Ten Days.—The patches of green colour have now coalesced, so that the whole body is discoloured. On some parts of the body the colour is of a reddish green, due to the presence of decomposed blood in the cellular tissue. The abdomen is now distended with gases, the products of decomposition. In India this distension has been known to occur in less than six hours, the average period being a little over eighteen hours. Much depends upon the season of the year. The colour of the eyes has not disappeared, but the cornea have fallen in. Relaxation of the *sphincter ani* takes place, and the superficial veins appear like reddish-brown cords. The nails still remain firm.

Fourteen to Twenty Days.—The colour of the surface is now bright green, with here and there patches of a blood and brown colour. The epidermal layer of the skin is raised in bullæ of varying size, in some places the skin being more or less stripped off. The nails are detached, and can be easily removed. The hair can be pulled from the scalp with ease. The body is now greatly distended with gases, and the features cannot be recognised, owing to the swollen condition of the face. The body is generally covered with vermin. In determining the time at which death occurred, it will be necessary to take into consideration the season of the year, as it is found that an advanced stage of decomposition may be present in from eight to ten days, with the thermometer ranging between 68° and 77° F., which in winter, with a temperature of from 32° to 50° would require twenty to thirty days. "Bodies green from putridity, blown up and excoriated, at the expiry of one month, or from three to five months after death (cœt. par.), cannot with any certainty be distinguished from one another" (Casper).

Three to Six Months.—During the above period the stage of colliquative putrefaction has set in. The

thoracic and abdominal cavities, due to the increased formation of gas, have burst. The bones of the cranium have more or less separated, allowing the brain to escape. The soft parts are more or less absorbed, and no recognition of the features is possible. The sex can only be positively made out by the presence of a uterus, or by the peculiar growth of hair on the pubes, which in woman only covers the pubes, but in man extends upwards to the navel.

Saponification. — Bodies exposed to the action of water, or buried in damp, moist soil, are apt to undergo certain changes, in the course of which they become saponified, and the formation of a substance known as *adipocere* is the result. Adipocere — *adeps*, lard, and *cera*, wax — is chiefly composed of margarate of ammonia, together with lime, oxide of iron, potash, certain fatty acids, and a yellow-coloured odorous matter. The melting point is 126·5° F. Adipocere has a fatty, unctuous feel, is either pure white or of a pale yellowish colour, and with the odour of decayed cheese. The formation of this substance "to any considerable extent is not likely to occur in less than three to four months in water, or six months in moist earth, though its commencement may take place at a much earlier period" (CASPER). The above quoted authority mentions a case in "which the remains of a fœtus were found imbedded in adipocere, and which fœtus was proved to have been buried in a garden exactly six months and three quarters." Taylor also records the case of a bankrupt who committed suicide by drowning, in which the muscles of the buttocks were found converted into adipocere in five weeks and four days at the longest.

Although the above statements may be accepted with regard to the formation of adipocere as far as European countries are concerned, they do not seem to be applicable to India, where the change appears

to be more rapid. Dr S. Coull Mackenzie in his valuable little book on "Medico-Legal Experiences in Calcutta," records a case of a young man whose body, recovered after seven days immersion in the river Hooghly, "was found to be in an advanced state of saponification," and the fleshy portions of undigested food in the stomach were converted entirely into adipocere. "Lastly," he writes, "in the hot, steamy, rainy months of September and October, in three of the cases above mentioned, saponification was found in bodies immersed in water, both externally and internally, in from two days to eight days ten hours. In the soft and porous soil of Lower Bengal during the rainy seasons, even in a wooden coffin, the change is very rapid, three or four days."

To explain the formation of adipocere, it has been supposed to be due to the decomposition of the muscular structures of the body, by which hydrogen and nitrogen are evolved, these combining to form ammonia, and, this coming in contact with the fatty acids of the fat, forms a soap. The process of saponification takes place most rapidly in young fat persons; next, in those adults who abound in fat, and in those whose bodies have been exposed to the soil of water-closets,—more rapidly in running than in stagnant water; and lastly, in those who have been buried in moist, damp soil, especially if the bodies have been piled one on the top of the other, the lowest being first saponified. The muscular tissue appears to be the first to undergo this change. In water the process is said to be completed in about five months, but in soil a period of two or three years appears necessary.

Mummification is of no medico-legal interest, as the causes which produce it are unknown, and no reliable data can be obtained as to the period of its accession, or the time required for its production.

TABLE showing the order in which the Internal Organs undergo Putrefaction :—

1. The Trachea.	9. The Heart.
2. The Brain of Infants.	10. The Lungs.
3. The Stomach.	11. The Kidneys.
4. The Intestines.	12. The Bladder.
5. The Spleen.	13. The Gullet.
6. The Omentum and Mesentery.	14. The Pancreas.
	15. The Diaphragm.
7. The Liver.	16. The Blood-vessels.
8. The Adult Brain.	17. The Uterus.

II.—INTERNAL.

ORGANS WHICH PUTREFY EARLY.

1. *The Trachea, including the Larynx.*—This rapid change in the trachea must be borne in mind, in order to avoid the error of attributing death to suffocation or drowning. An examination of the trachea should never be omitted.

2. *The Brain of Infants up to the First Year.*

3. *The Stomach.*—The first traces of putrefaction are seen in from four to six days after death. All the coats of the stomach are softened, but there is no excoriation, as is the case when corrosive poisons are taken. Emphysematous separation of the mucous coat may be present, but must not be confounded with the excoriation just mentioned.

4. *The Intestines.*—Casper declares that he does not remember any case in the course of his experience where the intestines were "found earlier putrefied than the stomach." In the course of putrefaction they become of a dark-brown colour, bursting, and allowing an escape of their contents; and they ultimately become changed into a dark pultaceous mass.

5. *The Spleen.*—This organ in some cases putrefies before the stomach and intestines; but, as a rule, it resists decomposition longer.

6. *The Omentum and Mesentery.*

7. *The Liver.*—This organ is not unfrequently found firm and dense some weeks after death. It putrefies earlier in new-born children than in adults. The convex surface first shows signs of putrefaction. The gall bladder also remains for some time recognisable.

8. *The Adult Brain.* — The brain of newly-born children, as mentioned before, soon putrefies. This is not the case in the adult brain. Putrefaction sets in not on the surface, but at the base of the brain. A wound of the brain causes it to putrefy more rapidly than if no injury be present.

Organs which Putrefy Late.

9. *The Heart.*

10. *The Lungs.*—Contemporaneously with the appearance of decomposition in the heart, the lungs also begin to show signs of putrefaction, though this condition may take place earlier.

11. *The Kidneys.*—These organs are long in yielding to the putrefactive process.

12. *The Bladder.*—Nearly all the other organs of the body are in a state of decomposition before this viscus becomes materially affected.

13. *The Gullet.*—This long remains firm, even after the stomach and intestines fail to be recognised.

14. *The Pancreas.*—The body must be far advanced in putrefaction before this gland becomes affected.

15. *The Diaphragm.*—This may be distinguished after the lapse of four to six months.

16. *The Blood-vessels.*—The aorta may be recognised after the body has been interred for fourteen months.

17. *The Uterus*—Of all the organs of the body, the uterus resists the putrefactive changes longer than any other organ.

TABLE showing some important Facts to be noticed with regard to Putrefaction :—

1. Earliest external indication of it.

   (1) *In a Body exposed to Air.*—Greenish colouration of the abdominal coverings.

   (2) *In a Body immersed in Water.*—Face, head, and ears, gradually extending from above downwards.

2. Earliest internal indication.—Found in the *trachea*, including the larynx.

3. Advanced putrefactive appearances to be expected in a body exposed to air, say from fourteen to twenty days at mean temperature, as regards—

   (1) *Epidermis.*—Raised here and there in blisters about the size of a walnut, in some places the size of a dinner plate, and quite stripped off.

   (2) *True Skin.*—Maggots cover the body, chiefly in the folds of the skin.

   (3) *Cellular Tissue.*—Blown up with gas.

4. Comparative time required to produce equal extent of putrefaction in a body.

   (1) *In Air.*—One week. One month.

   (2) *In Water.*—Two weeks. Two months.

   (3) *In Earth.*—Eight weeks. Eight months.

Does Lime hasten Putrefaction?—It is a very general opinion that it does. Careful experiment has, however, proved that lime neither retards nor hastens putrefaction, but that it prevents the escape of the gases produced during the process by absorbing them; it is, therefore, a good and safe deodoriser, and in this property its true value lies.

POST MORTEM EXAMINATIONS.

The following are some of the Instructions issued to Medical Inspectors by the Crown Office in Scotland, slightly modified :—

I.—Part of General Directions.

13. When any portions of the body, or any substances found in or near it, are to be preserved for further examination, they ought never to be put out of the custody of the Inspectors, or of a special law-officer. They must be locked up in the absence of the person who keeps them. When they are to be transmitted to a distance, they should be labelled, and the labels signed by the inspectors; and after being properly secured and sealed, they should be delivered by the inspectors themselves, or the special law officer whose duty it is to see them delivered into the hands of the parties for whom they are intended.

II.—Necessary Implements.

14. Besides the ordinary instruments used in common dissections, the inspector should be provided with a foot-rule for measuring distances, and a glass measure graduated to drachms, for measuring the quantities of fluids, two or three stoneware jars of medium size, or when these cannot be had, a few clean bladders, for carrying away any parts of the body which it may be necessary to preserve for future examination, and in cases of possible poisoning, three or four bottles of eight, twelve, and sixteen ounces, with glass stoppers or clean corks, for preserving fluids to be analysed. The common square green glass pickle bottles are very suitable, and can generally be obtained. No bottle or jar should be used until it has been thoroughly washed under the supervision of one of the inspectors. In cases of infanticide a balance, having a flat scale pan with a foot-rule painted on it, is of great use; on it the infant may be stretched, weighed, and measured at one operation. Paper, pens, ink, and sealing-wax should also be provided.

15. All distances, lengths, surfaces, and the like, whose extent may require to be described, ought to be accurately measured ; and the same rule ought to be followed in ascertaining the volume of fluids. When large quantities of fluids are to be measured, any convenient vessel may be used, whose capacity is previously ascertained by the inspectors. Conjectural estimates and comparisons, however common, even in medico-legal inspections, are quite inadmissible.

III.—External Aspect, and Examination of the Body.

16. The importance of the external examination, and the particulars to be chiefly attended to in performing it, will vary in

different cases with the probable cause of death. It comprehends an examination—(1) Of the position of the body when found, as well as of all external injuries or marks presented by it. (2) Of the vicinity of the body, with a view to discover the objects on which it rested, or from or upon which it may have fallen, marks of a struggle, signs of the presence of a second party about the time of death or after it, weapons or other objects the property or not the property of the deceased, the remains of poisons, marks of vomiting; and where marks of blood are of importance, and doubts may arise as to their really being blood, the articles presenting them must be preserved for further examination. (3) Of the dress, its nature and condition, stains on it of mud, sand, or the like, of blood, of vomiting, of acids, or other corrosive substances, marks of injuries, such as rents or incisions; where injuries have been inflicted on the body, care should be taken to compare the relative position of those on the body and those on the clothes; and where stains, apparently from poison, are seen, the stained parts are to be preserved for analysis. (4) Ligatures, their material and kind, as throwing light on the trade of the person who applied them; the possibility, or impossibility of the deceased having applied them himself; their sufficiency for accomplishing their apparent purpose, etc.

17. The inspectors will commence the examination of the body itself by surveying the external surface and openings. Before cleaning it they will examine it on all sides, not neglecting the back, as is often done, and look for marks of mud, blood, ligatures, injuries, stains from acids, and the like; foreign bodies, or injuries within the natural openings of the body, viz., the mouth, nostrils, ears, anus, vagina, and urethra. If there are impressions of finger-marks, they will consider which hand produced them. If there be any doubt about stains being blood, the skin presenting them must be preserved for analysis. If there be acid stains, or other probable remains of poison, or any foreign matter, the nature of which may require to be determined by analysis, these must also be preserved. The ordinary places for the impressions of ligatures are the neck, the wrists, the ankles, and the waist. The degree of warmth of the trunk and extremities, the presence or absence of cadaveric rigidity, and whether it exists equally in the upper or the lower extremities, should be noted in this stage of the proceedings; in other cases the progress of putrefaction, as indicated by the odour of the body, the looseness of the cuticle, the colour of the skin, and formation of dark vesicles on it, the evolution of air in the cellular tissue, the alteration of the features, the softness of the muscles, the shrivelling of the eyes, the looseness of the hair and nails.

18. In this part of the examination it will sometimes be necessary to observe the particulars by which the body may be identified. These are numerous. But the most important are the stature, the age and sex, the degree of plumpness, the size and form of the nose and mouth, the colour of the eyes and hair, the state of the teeth, warts, nævi, deformities, scars of old abscesses, ulcers, and wounds, and, if a woman, marks of her having had one or more children.

19. The body is next to be washed, if necessary, and the hair of the head shaved, or at least closely cut; and a thorough examination of the whole integuments is to be made. At this stage the inspectors will look particularly for the appearance of lividity, noting its chief seat and its relation to the posture in which the body was found—for impressions on the skin of objects on which it had rested—for marks of injuries, more especially contusions, taking care to ascertain their real nature by making incisions through the skin—for marks of disease, such as eruptions, ulcers, and the like—for marks of burning—for marks of concealed punctures in the nostrils, mouth, external openings of the ears, the eyes, the nape of the neck, the arm-pits, the anus, the vagina, and beneath the mammæ or scrotum; in infants, also in the fontanelles and the whole course of the spine. At this stage, wounds and other injuries should be carefully examined according to the directions given in Division V. *(infra)*. Where the injury may have caused loss of blood, the presence or absence of pallor of the skin, lining membrane of the mouth and the gums ought to be noted.

IV.—Dissection, or Internal Examination of the Body.

20. In commencing the dissection of the body, it must be laid down as an invariable rule that all the great cavities should be examined, and also every important organ in each, however distinctly the cause of death may seem to be indicated in one of them. It is right to examine the cavity of the spine, and at all events its upper portion, in any case where an unequivocal cause of death has not been discovered elsewhere.

21. In examining the organs situated in the several cavities of the body the inspectors must be guided in a great measure by their ordinary anatomical and pathological knowledge.

22. The inspectors should begin with that cavity over which there is a wound or other mark of injury. Or, if there be an injury on the extremities, the dissection ought to commence there. In the absence of any such guide, that cavity should be taken first where the circumstances of death, so far as they are ascertained, may lead the inspectors to expect unusual appearances. In other cases, the abdomen should be first opened but *not* dissected, and a general survey made of the parts exposed, without disturbing them materially; the position of the diaphgram being determined by examining it with the hand, then the thorax is immediately to be examined, unless there is good reason for doing otherwise. The reasons for this method of procedure are as follow:—If the abdominal organs are removed, and the veins cut, the blood in the heart may drain away through the venæ cavæ, and error result. If, on the other hand, the thorax be first opened, the relation of the abdominal organs to each other cannot be clearly made, owing to the relaxation of the diaphragm, due to the severing of its thoracic connections. Again, if the thorax be first opened, the position of

the diaphragm cannot be determined. The inspectors may begin with the head, which may be examined thoroughly in the first instance, afterwards the chest and belly, as above described; the spine being reserved till the conclusion. Wherever unusual appearances are discovered in the first cursory survey, the anatomical examination ought in general to be begun there.

23. In examining the several regions of the body it is to be observed that wherever a wound, or other obvious injury of the external parts, lies in the way of the ordinary incisions, that part must be avoided, so as to leave the external injury unaltered.

24. The most approved mode of opening the head in medico-legal cases is, after dividing the integuments from ear to ear, and reflecting the scalp over the forehead and occiput, to make the usual circular incision through the skull, about an inch above the orbits in front, and over the occipital protuberance behind, using the saw lightly and carefully after the outer table of the skull has been divided, so as to avoid injuring the membranes of the brain; and to raise the skull-cap from before backwards, taking care to detach the dura mater from the skull with the handle of the scalpel or a spatula where it adheres firmly. The chisel and mallet should never be used where there is any chance of finding a fracture of the skull; for how could it be distinguished from a fracture made with the mallet? Should the dura mater be firmly adherent to the skull-cap, the better practice is to divide it carefully, so as to remove both at the same time. Tearing the membrane and crushing the brain substance are thus avoided. In infants and young children this mode of procedure is most necessary, as in them the dura mater is, as a rule, adherent.

25. The ordinary mode of examining the membranes of the brain, and the brain itself, answers well in medico-legal dissections. Effusions of fluid within the skull should always be measured. After the brain is removed, the dura mater ought to be stripped from the base of the skull to facilitate the search for fractures there, which will, of course, indicate external violence. After the removal of the brain, the upper part of the spinal canal should be examined through the foramen magnum before any part of its course be laid open; and search should be particularly made for dislocation or other injury in the region of the atlas and dentata. In cases of fatal fractures of the head, the strength of the bones should be attended to. In cases of extravasation within the head, the state of the coats of the cerebral arteries should be examined.

26. The best mode of opening the spine is, after having finished the examination of the brain, to cut through the integuments from the occiput to the coccyx — to lay the vertebræ thoroughly bare on each side by cutting away the muscles — to make an incision with the saw on each side of the skull, from the postero-inferior angle of the parietal bones into the lateral edge of the occipital hole—to remove the triangular portion of the occipital bone thus

detached, and then to cut the rings of the vertebræ on each side with the bone-nippers or spine-knife, beginning with the atlas. In these cases preference should be given to the saw, by which the operation is not only more easily accomplished, but there is no risk of confounding previous fracture with that made in dissecting. Where there is reason to think that the bones are injured, the laying open of the canal should stop at the distance of two or three vertebræ from the injury, and the injured bones, with two or three adjacent vertebræ on each side, should be removed entire before the examination is extended further down the spine.

27. The organs of the throat may be examined, either by dividing the lower jaw-bone at the chin, cutting the soft parts close to the inner surface of each half of the bone backwards, and then turning the two segments outwards; or, by freely reflecting the skin of the throat, separating the soft parts from the inside of the lower jaw, the knife being carried parallel with and close to the bone, drawing the tongue out below the chin, and then continuing the dissection backwards.

28. The best mode of examining the organs situated in the throat is, after detaching the soft parts from the lower jaw, as advised in Sect. 27, to dissect the soft palate from the bone, and proceeding backwards, to detach the whole soft parts from the base of the skull and vertebræ down to the sternum, leaving them connected with the organs in the chest. Besides the ordinary points to be attended to in this part of the examination, the presence of venereal or other ulcerations is a matter requiring attention in some cases.

29. It is necessary to examine the pharynx and gullet, the larynx, trachea, and its greater ramifications; the lungs, the heart, and the great vessels with particular care, because here are most frequently found the causes of sudden natural death. In examining the heart each auricle and each ventricle ought to be laid open by an independent incision of its parietes; and this should not intersect either any of the valvular openings or the septum cordis.

30. For laying open the chest and abdomen, the most convenient method is to make an incision down the fore part of the neck, chest, and abdomen to the pubes; then cutting from the peritoneum upwards, to dissect back the integuments and muscles of the chest, and examine the abdomen, as in Sect. 22; next, divide the cartilages of the ribs, and, cutting upwards, close under them, to raise the cartilages along with the sternum. In separating the sternum from the clavicles, care must be taken not to wound the subjacent vessels; and this may be avoided by the dissector moving each shoulder so as to show the exact position of the sterno-clavicular joints, and then dividing both joints cautiously. In dividing the cartilages of the ribs, the saw is sometimes necessary. The cartilages should be cut as far from the sternum as possible, to give free space for the subsequent examination.

31. In inspecting the organs in the chest, a cursory examination should be first made by turning them over, ascertaining the nature and measuring the quantity of effused fluids, feeling for fractures of the ribs, tumours, or other diseases, and opening the pericardium to obtain a view of the heart. The most convenient course to pursue next is, without moving the heart from its place, to lay open its several cavities, in order to judge of the quantity and state of the blood in both sides of that organ. For this purpose the following incisions should be made :—The *first*, beginning close to the base, is carried along the right border of the heart directly into the right ventricle towards the apex, care being taken not to cut the septum. This lays open the right ventricle. The *second* incision, opening up the right auricle, begins midway between the entrances of the venæ cavæ, ending just in front of the base. The *third*, for exposing the left auricle, commences at the left superior pulmonary vein, and ends just in front of the base, close to the coronary vein, care being taken not to wound it. The *fourth*, displaying the left ventricle, commences behind the base, and ends close to the apex. If the blood is in a fluid state, the quantity contained in the right auricle may be materially affected by the head being examined previously, as the blood may have escaped from the heart by the jugular veins. The whole of the organs in the chest—namely, the lungs, heart, and gullet—together with the parts dissected downwards from the throat, should now be removed in one mass, in order to examine them in detail on a table. But previously two ligatures should be applied on the gullet, just above the cardiac orifice of the stomach, and the division made between them.

32. The organs in the abdomen ought to be turned over, like those of the chest, before any one of them is minutely examined, but before the thorax is opened, for the reasons given in Sect. 22. In the subsequent examination, that organ is to be first proceeded with in which there may appear to be disease.

V.—Examination in Cases of Wounds and Contusions.

33. In a *post-mortem* examination, the most approved mode of examining these injuries is, if they be situated over great cavities, to expose the successive structures in the manner of an ordinary dissection, observing carefully what injuries have been sustained by the parts successively exposed before they are divided. Wounds ought not to be probed, especially if situated over any of the great cavities. The depth of a wound is best ascertained by careful dissection and exposure of the parts involved ; but after this is done, the thickness of the tissues penetrated may be measured by the probe.

34. The seat of the wounds must be described by actual measurement from known points, their figure and nature also carefully noted, and their direction ascertained with exactness.

35. Before altering by incisions the external appearances of injuries, which should never, if possible, be done, care must be taken to consider what weapon might have produced them, and if a particular weapon be suspected, it should be compared with them. The wounded parts should be cut out entire, and carefully preserved.

36. Apparent contusions must be examined by making incisions through them; and the inspectors will note whether there be a swelling or puckering of the skin; whether the substance of the true skin be black through a part or the whole of its thickness; whether there be extravasation below the skin or in the deeper textures, and whether the blood be fluid or coagulated, generally or partially; whether the soft parts below be lacerated, or subjacent bones injured: and whether there be blood in contact with the lacerated surfaces. By these means the question may be settled whether the contusions were inflicted before or after death.

37. In the cases of wounds, too, the signs of vital action must be attended to, especially the retraction of the edges, adhesion of blood to their surfaces, or the injection of blood into the cellular tissue around, or the presence of the signs or sequelæ of inflammation. Hypostasis must not be mistaken for vascular injection.

38. When large arteries or veins are found divided, care must be taken to corroborate the presumption thus arising by ascertaining, in the subsequent dissection, whether the great vessels, lungs, liver, and membranous viscera of the abdomen be unusually free of blood.

39. In the course of the dissection of wounds, a careful search must be made for foreign bodies in them. When firearms have occasioned them, the examination should not be ended before discovering the bullet, wadding, or other article, if any, lodged in the body; and whatever is found must be preserved. When the article discharged from firearms, or when any other weapon has passed through and through a part of the body, the two wounds must be carefully distinguished by their respective characters, especially as regards their comparative size, inversion or eversion, smoothness or laceration, of their edges, their roundness or angularity, and the comparative amount of bleeding from each. In gunshot injuries, the presence or absence of marks of gunpowder should be noted.

40. When wounds are situated over any of the great cavities, they ought not to be particularly examined till the cavity is laid open; and in laying open the cavity, the external incisions should be kept clear of the wounds.

41. When the discoloured state of a portion of the skin is such as to render it doubtful whether it is due to injury or to changes after death, an incision should be made to ascertain whether there is blood effused into the textures, constituting true ecchymosis, or merely gorging of the vessels of the skin, or discolouration from infiltration of the colouring matter of the blood, which takes place

in depending parts of a dead body. The term suggillation should be avoided, as it has been used in opposite senses by Continental and British authors. The respective expressions, "discolouration from extravasted blood," and "lividity after death," are preferable.

VI.—Examination in Cases of Poisoning.

42. In examining a body in a case of suspected poisoning, the inspectors should begin with the alimentary canal, first tying two ligatures round the gullet, above the cardiac orifice of the stomach, two round its pyloric end, and a third at the sigmoid flexion of the colon, then removing the stomach and entire intestines: next dissecting out the parts in the mouth, throat, neck, and chest in one mass; and, finally, dissecting the gullet, with the parts about the throat, from the other organs of the chest. The several portions of the alimentary canal may then be examined in succession.

43. Previous to commencing the dissection in cases of supposed poisoning, the inspectors should make such inquiries as may enable them to form an opinion as to the class of poison to which the death may be traceable, and thus to guide them as to the conclusions to be come to from the presence, or it may be the complete absence, of any marked appearance explaining the cause of death.

44. The medical inspectors may afford most important aid to the law officers in investigating the history of cases of supposed poisoning. For this purpose minute inquiry should be made into the symptoms during life, their nature, their precise date, especially in relation to meals or the taking of any suspicious article, their progressive development, and the treatment pursued. It is impossible to be too cautious in collecting such information, and, in particular, great care must be taken to fix the precise date of the first invasion of the symptoms, and the hours of the previous meals. The same care is required in tracing the early history of the case, where the inspector happens to visit the individual before death; and if suspicions should not arise till his attendance has been going on for some time, he ought, subsequently to such suspicions, to review and correct the information gathered at first, especially as to dates. All facts thus obtained should be immediately committed to writing.

45. Besides inspecting the body and ascertaining the history of the case, the inspectors may afford valuable assistance to the law officers in searching for suspicious articles in the house of the deceased. These are—suspected articles of food, drink, or medicine; the vessels in which they have been prepared or afterwards contained; the family stores of the articles with which suspected food, etc., appears to have been made. All such articles must be secured, according to the rules in Sect. 13, for preserving their identity. In this examination the body-clothes, bed-clothes, floor, and hearth should not be neglected, as they may present traces of vomited matter, acids spurted out or spilled, and the like.

46. When a medical man is called to a case during life, where poisoning is suspected, he ought as soon as possible, to follow the instructions laid down for securing articles in which poison may have been administered.

47. In the same circumstances, it is his duty to observe the conduct of any suspected individual, were it for no other reason than to prevent the remains of poisoned articles from being put out of the way, and to protect his patient against further attempts.

48. The whole organs of the abdomen must be surveyed, and particularly the stomach and whole tract of the intestines, the liver, spleen, and kidneys, the bladder; and in the female, the uterus and its appendages. The intestines should in general be split up throughout their whole length; and it should be remembered that the most frequent seat of natural disease of their mucous membrane is in the neighbourhood of the ileo-cæcal valve, and that, next to the stomach, the parts most generally presenting appearances in cases of poisoning are the duodenum, upper part of jejunum, lower part of ileum, and rectum.

49. In cases where the possibility of poisoning must be kept in view, and where matters may require to be procured for chemical analysis, it is essential to be sure that all instruments, vessels, and bladders used are scrupulously clean.

50. When any unusual odour is perceived, either in the blood in the course of making the dissection, or in the stomach when opened, it ought to be carefully observed, and if possible identified by all the medical men present. In this way alcohol, opium, prussic acid, oil of bitter almonds, and other odorous poisons may be recognised. The smell of the contents of the stomach ought always to be noted whenever it is opened, as the smell often alters rapidly.

51. The stomach and intestines should be taken out entire, and their contents emptied into separate bottles. If the stomach or part of the intestines present any remarkable appearance, examination may be reserved, if convenient, till a future opportunity; but in every circumstance it must be preserved and carried away, as it may itself be an important article for analysis. The throat and gullet may be examined at once, and preserved with their contents, which, if abundant, may be kept apart in a bottle. In addition to the alimentary canal and its various contents, portions of the solid organs of the body ought to be secured for analysis. The most important are the liver, spleen, and kidneys. A part of the liver, at least a fourth part, should be secured in every case of supposed poisoning; and in cases where the fatal illness has been of long duration, and therefore only traces of the poison may remain in the body, the whole of the liver, the spleen, and both kidneys should be secured. A portion of the blood, especially when the odour of any volatile poison is perceived, should be at once put into a bottle, closed by a good cork or stopper.

52. No person ought to undertake an analysis in a case of suspected poisoning unless he be either familiar with chemical

researches, or have previously analysed with success a mixture of organic substances, containing a small proportion of the poison suspected.

53. All persons undertaking an analysis should bear in mind that the opinion of some other person practised in toxicological researches may be required ; and they should therefore take care, when practicable, to use only a portion of the several articles preserved for analysis. The identity of the subjects for analysis must be secured by the rules in Sect. 13.

VII.—Examination in Cases of Suffocation.

54. In cases of suspected drowning, the inspectors will observe particularly whether grass, mud, or other objects be clutched by the hands, or contained under the nails ; whether the tongue be protruded or not between the teeth ; state of the penis ; whether any fluid, froth, or foreign substances be contained in the mouth, nostrils, trachea, or bronchial ramifications ; whether the stomach contains much water ; whether the blood in the great vessels be fluid. Careful pressure should be made upon the lungs, any fluid contained in them is thus forced into the bronchial tubes and trachea, and its nature observed. When water with particles of vegetable matter or mud is found within the body, these must be compared with what may exist in the water in which the body was discovered, and should be preserved for further scientific investigation, if requisite. Marks of injuries must be compared diligently with objects both in the water and on the banks near it, and especial attention given to the question—whether any observed injuries had been sustained by the body before or after death.

55. In cases of suspected death by hanging, strangling, or smothering, it is important to attend particularly to the state of the face as to lividity, compared with the rest of the body ; the state of the conjunctiva of the eyes as to vascularity ; of the tongue as to position ; of the throat, chin, and lips, as to marks of the nails, scratches, ruffling of the scarf-skin, or small contusions ; the state of the blood as to colour and fluidity ; the state of the heart as regards the amount of blood in its several cavities ; the state of the trunk and branches of the vena cava in the abdomen as regards distension with blood ; and the state of the lungs as regards congestion, rupture of any of the air cells, and small ecchymoses under the pleura, or the pericardium. The mark of a cord or other ligature round the neck must be attentively examined ; and here it requires to be mentioned that the mark is often not distinct till seven or eight hours after death, and that it is seldom a dark livid mark, as is very commonly supposed, but a pale greenish-brown streak, presenting no ecchymosis, but the thinnest possible line of bright redness at each edge, where it is conterminous with the sound skin. Nevertheless,

effusions of blood and lacerations should be also looked for under and around the mark, in the skin, cellular tissue, muscles, cartilages, and lining membrane of the larynx and trachea. Accessory injuries on other parts of the body, more especially on the chest, back, and arms, must also be looked for, as likewise the appearance of blood having flowed from the nostrils or ears, and the discharges of fæces, urine, or semen. In cases where death may be due to the emanations from burning fuel or other poisonous vapours, a small phial should be filled with the fresh blood, and securely corked for further investigation, if requisite.

VIII.—Examination in Cases of Burning.

56. In supposed death by burning, the skin at the edge of the burns should be carefully examined for redness, or the appearance of vesicles containing fluids.

IX.—Examination in Cases of Criminal Abortion.

57. In suspected criminal abortion, when the woman survives, the chief points for inquiry are:—The proofs of recent delivery, the ascertaining of facts tending to show that she has been subjected to manœuvres with instruments, and the occurrence of symptoms traceable to the action of any of the drugs reputed as capable of causing abortion.

When the woman has died, the points requiring special attention at the dissection are:—The state of the womb, as regards its size and the condition of its lining membrane, in reference to the probable period of delivery; the condition of the intestinal canal, in reference to the action of irritant drugs; of the mucous membrane of the bladder, in reference to the action of cantharides; close inspection of the womb and vagina, in reference to mechanical injuries, especially punctured wounds; and any appearances that the death may have been caused by inflammation in the organs of the pelvis, or by bleeding from the wound.

X.—Examination in Cases of Infanticide.

58. In cases of suspected infanticide, certain specialities must be borne in mind. The cavity of the head should be laid open with a pair of scissors. In opening the abdomen, the navel should be avoided, so that the state of the vessels of the navel-string may be examined correctly. This is done by carrying two incisions from the ensiform cartilage to each of the anterior superior spines of the ilia, and by deflecting downwards the triangular flap thus formed.

59. The inquiry in cases of infanticide should be conducted with reference to the five following distinct questions:—(1) The probable degree of maturity of the child? (2) How long it has been

dead? (3) Whether it died before, during, or after delivery, and how long after? (4) Whether death arose from natural causes, neglect, or violence? and (5) Whether a suspected female be the mother of the child?

60. The points to be attended to for ascertaining the probable degree of maturity of the child are:—The general appearance and development, the state of the skin, its secretions, and its appendages; the hair and nails; the presence or absence of the pupillary membrane; the length and weight of the whole body; whether the navel corresponds or not with the middle of the length of the body; the situation of the meconium in the intestines; the site of the testicles in the case of males, and in either sex the size of the point of ossification in the lower epiphysis of the thigh-bone. This is easily observed by making an incision across the front of the knee into the joint, pushing the end of the thigh-bone through the cut, slicing off the cartilaginous texture carefully until a coloured point is observed in the section, and then. by successive very fine slices, ascertaining the greatest diameter of the bony nucleus. This does not exist previous to the thirty-sixth week of gestation, and in a mature child is about one-fourth of an inch in diameter. Has the infant been washed? Absence or presence of vernix caseosa. Nature and character of the wrappings, if any, found on the child.

61. The points of chief importance in reference to the period which has elapsed after death are those specified in the last clause of Sect. 17—it being borne in mind that the bodies of infants are often concealed in ash-pits and dunghills, and that in these circumstances putrefaction is very rapid.

62. The circumstances which indicate whether the child died before, during, or after parturition, and how long after it, are the signs of its having undergone putrefaction within the womb; the marks on the crown, feet, buttocks, shoulders, etc., indicating presumptively the kind of labour, and whether it was likely to have proved fatal to the child; the state of the lungs, heart, and great vessels, showing whether or not it had breathed; the nature of the contents of the stomach and of the intestines; the presence of foreign matters in the windpipe; the state of the umbilical cord, or of the navel itself, if the cord be detached.

63. In order to examine properly the state of the lungs, heart, and great vessels, with a view to determine whether or not the child had breathed, the inspection should be made in the following order:—Attend, first, to the situation of the lungs; how far they rise along the sides of the heart; to their colour and texture; whether they crepitate or not. Then secure a ligature round the great vessels at the root of the neck, and another round the vena cava above the diaphragm. Cut both sets of vessels beyond the ligatures, and remove the heart and lungs in one mass, which must be weighed and put into water, to ascertain whether the lungs, with the heart attached, sink or swim. In the next place, put a ligature round the pulmonary vessels, close to the lungs,

and cut away the heart by an incision between it and the ligature. Lastly, ascertain the weight of the lungs; whether they sink or swim in water; whether blood issues freely or sparingly when they are cut into; whether any fragments swim in the instances where the entire lungs sink; and in every instance of buoyancy, whether fragments of them continue to swim after being well squeezed in a cloth.

64. The general question to be considered in relation to the cause of death is, whether the appearances are such as to be traceable to the act of parturition, or whether they indicate some form of violent death. The directions given in Divisions V., VI., and VII. apply to infants as well as adults; but the following points are specially to be noticed in cases of supposed infanticide:—

In relation to wounds and contusions, the possibility of minute punctured wounds of the brain or other vital organs; in reference to injuries of the head, the effusion of blood under the scalp, not in the situation where it could have been produced during labour, or fracture of the bones not producible by compression of the head during labour, and not connected with defective ossification of the skull; in reference to the allegation that the head was injured by the child suddenly dropping from the mother, when not recumbent, the presence of sand or other foreign matters on the contused scalp, and the existence of more than one injury of the head; in relation to suffocation, the external and internal signs of this form of death—marks of compression of the mouth, and nose, and throat, and the presence of foreign matters in the mouth and throat, air passages, gullet, or stomach, especially if the body be found in contact with similar substances; in reference to bleeding from the navel-string, a bloodless state of the body, without any wound to account for it; in reference to poisons, most commonly narcotics, the absence of any of the above appearances, with an otherwise healthy state of the body; in reference to starvation and exposure, emaciation of the body, absence of food from the stomach, and an empty, contracted condition of the intestines; in reference to the possibility of the child having been suddenly expelled, and having fallen on the floor or into privies, etc., the state of the navel-string is to be noted—whether long or short, whether remaining attached to the child and connected with the after-birth, indicating rapid labour, or, if divided, whether it had been cut or torn across. Nature of the ligature used, if any.

65. The circumstances noticed in Sects. 60, 61, 62, 63, 64, compared with the signs of recent delivery in the female, will lead to the decision of the question whether the suspected female be the mother of the child. These circumstances may be shortly recapitulated as being the signs of the degree of maturity of the child—the signs on the body of the kind of labour, the signs which indicate the date of its death, and the interval which elapsed both between its birth and death, and between its death and the inspection.

EXHUMATIONS.

It becomes necessary sometimes to exhume the bodies of persons who have been buried. The cases which generally call for this, always unpleasant, and in most cases disgusting proceeding, are those where a suspicion of poisoning or violence has arisen some little time after the burial of the supposed victim. Or the necessity may arise to show that the body buried is that of a person whose death it is absolutely necessary to prove. In the case of Livingstone, though this can scarcely be called a case of exhumation, yet an examination some months after death of the arm of the corpse alleged to be that of Livingstone, proved the existence of a badly united fracture which the deceased was known to have had.

In conducting the exhumation, it is necessary that the medical experts should be present to see the body removed from the coffin, and also any person or persons who may be in a position to speak as to the identity of the corpse—as, for instance, those who dressed it and prepared it for burial. The person who made the coffin may also be of assistance to speak as to its identity. As soon as the medical men are armed with the proper authority, no time should be lost in order to get the body as fresh as possible, and at once prove or disprove the accusation of the crime, which, in the case of innocent persons, cannot be too quickly removed. The best time to take up the body, if in the summer, is early in the morning: and, in all cases, the examination, if possible, should be made during daylight. Disinfectants may be sprinkled on the grass, on the coffin, and around but not on the body when lying on the table during the inspection. Everything necessary for making a medical inspection should be taken; and also a table on which to place the body. A pail containing a solution of chloride of lime, for the inspectors to wash their hands, should be close at hand. And it is as well to expose

the body for a short time to the air before beginning the inspection. There is seldom any risk to health in removing a single body, yet certain precautions are necessary ; thus it is as well to take a little spirits, and also to stand on the windward side of the corpse. Vaults should not be entered as soon as they are opened, but time allowed for their ventilation. No *post-mortem* should ever be conducted on an empty stomach. Carefully note the amount of preservation of the coffin, and, if broken, if any of the surrounding earth is in contact with the body. This precaution is necessary in cases of suspected mineral poisoning (as in arsenic, etc.), and it is as well also to save one or two pounds of the earth immediately above the coffin for analysis. The body may then be examined externally, any hair left on head or face preserved for identification ; and then an inspection of all the cavities made, the contents of the stomach and bowels being placed in dry earthenware jars or glass bottles, corked and capped with thin indiarubber skin, and so tied and sealed that the string must be cut or the seals broken in order to open them. The ends of the string should be sealed in the presence of the authorities. In the examination, the instructions previously given should be carefully followed. All injured or diseased parts should be removed and preserved whenever this is practicable. Soft parts not intended for analyses may be preserved in a concentrated solution of salt.

Beyond what Period is it useless to Exhume a Corpse?—There is no scientific limit, for even the bones may show that violence has been used, or may point to the identity of a corpse, as in the case of Livingstone just mentioned. Pregnancy may be detected. The medical inspectors must proceed with the inspection unless they can positively say that the progress of decay is such as to render the examination nugatory in relation to its special objects. Casper mentions the case of a man whose body was three times

exhumed for different purposes. In Scotland the law imposes a limit of twenty years, but in England the law is silent on the point; in France a limit of ten years from the date of the supposed crime; and in Germany, the limit is thirty years, if the offence is that punishable with death, the time varying from three to thirty years with the nature of the crime.

EXAMINATION OF LOCALITIES.

This is generally done by the police, but it may sometimes be undertaken with advantage by experts, and it is desirable that the medical inspectors should have an opportunity of viewing the body before it is undressed, or moved from the spot where it was first found. If the body has been previously removed or meddled with, they ought to inform themselves accurately as to its original position, for in many cases it is material that they personally visit the place where it was first seen, and they should inquire minutely into all the particulars connected with the removal of it. Important articles of evidence are often overlooked, owing to the absence of a medical man, to whom alone their importance would have been apparent.

There is considerable difference of opinion as to the size of a footprint on the ground, Mascar of Belgium asserting that it is *smaller* than the foot that made it, Caussè on the contrary that it is usually *larger.* It should be borne in mind that the size of the footprint varies in running, walking, and standing, being smallest in running and largest when the individual is standing. This fact may account for the difference of opinion of the two observers just mentioned. A mark in the footprint showing that the sole of the foot had been patched, or in the case of the naked foot that there was some deformity of the toes would of necessity be important. The mark of the naked foot smeared with blood has, in several cases, led to the identification of

the culprit. Casts of footprints may be taken with wax, or perhaps better, with equal parts of Roman cement, fine sand, and plaster of Paris. Sprinkle this mixture over the footprint, and then place a cloth over it. Gradually moisten the cloth, so that the water may slowly percolate, until the mixture is quite moist; now lift the cloth, and allow the cement to harden. Another method suggested by M. Hougolin is as follows: — The footprint or the mark is gradually heated by holding over it a pan containing burning charcoal, and then powdered stearic acid or paraffin is sprinkled into the footprint so heated, and allowed to cool. From the mould so taken, a plaster of Paris cast can be made. The stearic acid may be powdered by dissolving it in spirit and then pouring the solution into water. When the footprints are in snow a cast of them may be taken in gelatine.

ASSAULTS AND HOMICIDE.

Assault.—Every act of attack upon the person of another is an assault in law, whether it injure or not; nor is it necessary that the act done take effect. Spitting on any one is an assault. No provocation by word, whether written or spoken, can justify an assault, though it may mitigate the offence. If a medical man unnecessarily strip a female patient naked, under pretence that he cannot otherwise judge of her illness, it is an assault if he himself take off her clothes (R. *v.* Rosinski, 1 Mood C.C., 12). So, where a medical man had connection with a girl fourteen years of age, under the pretence that he was thereby treating her medically for the complaint for which he was attending her, she making no resistance solely from the *bona fide* belief that such was the case, this was held to be certainly an assault, and probably a rape (R. *v.* Case, 1 Den. 580; 19 L. J. [M.C.] 174). By a recent Act of Parliament such an act is now held to constitute a rape.

Battery.—This includes beating or wounding. A touch of the finger, however slight, is included under this term.

Homicide.—In Scotch law homicide is held to be committed only where a distinctly self-existent human life has been destroyed. Destruction of an unborn child, however short a time before delivery may be criminal, but is not homicidal. In the same country criminal homicide is divided into two classes :—

(1) Murder. (2) Culpable Homicide.

1. *Murder* is constituted in law by any wilful act causing the destruction of human life, whether plainly intended to kill, or displaying such utter and wicked recklessness as to imply a disposition depraved enough to be wholly regardless of the consequences. Murder may be the result of personal violence, poison, or by the committal of some other serious crime, as where any one causes the death of a woman in the attempt to procure criminal abortion, rape, or by the exposure of an infant which results in its death. The use of weapons is not essential.

2. *Culpable Homicide.*—The name applied in law to cases where the death of a person is caused or materially accelerated by improper conduct of another, and where the guilt does not come up to the crime of murder :—

(*a*) Intentional killing of another in circumstances implying neither murder on the one hand, nor justifiable homicide on the other—*e.g.*, if a person exceed moderation in retaliation for an injury, or kill another when the danger to which he was exposed is passed.

Every charge of murder is held to include a charge of culpable homicide, and the Jury, if they see cause, may find that culpable homicide only has been committed.

(*b*) Homicide, by doing of any unlawful, or any rash and careless act, from which death results, though not foreseen as probable —*e.g*, using firearms in a public street, etc.

(*c*) Homicide, resulting from negligence or rashness in the performance of a lawful duty—*e.g.*, a signalman on a railway forgetting to alter the points, and thus causing a collision and loss of life. In England this would amount to manslaughter.

Justifiable Homicide. — Self-defence; hanging a prisoner properly sentenced to death; killing another to prevent murder, if prevention can avail in no other way. In self-defence, the person killing must be in *reasonable dread* of death at the hand of his adversary.

In England there is—1. Murder. 2. Manslaughter, 3. Justifiable Homicide.

Murder, according to Lord Coke (3 Inst. 47), is constituted "where a person of sound memory and discretion, unlawfully killeth any reasonable creature in being, and under the King's peace, with malice aforethought, either expressed or implied."

In England the killing must be committed with malice aforethought. Malice may be expressed or implied.

In Scotland malice aforethought is not necessary (5 Irv. 525, and 40 S. J. 92, and 5 S. L. R. 20).

The law in both countries appears to differ more in terms than in practice. In England, if an injured party live for one year and a day, and then die, death is not attributed to the injury; but in Scotland, although no definite time is fixed, yet no case would I believe be entertained at any lengthened period after the commission of a homicidal act. The longest interval according to Taylor at which conviction has taken place from indirectly fatal consequences was *nine months.*

In the United States, as a rule, the crime of murder admits of two degrees: in the *first*, where the act is intentional or is the result of an attempt at burglary, rape, arson, or by poison; otherwise the crime falls under the *second* degree.

Responsibility of Assailants.—It is held in law that every man is responsible for consequences of his acts. Lord Hale observes:—"It is sufficient to constitute murder, that the party dies of the wound given by the prisoner, although the wound was not originally mortal, but became so in consequence of negligence on unskilful treatment, but it is otherwise where death

arises not from the wound, but from unskilful applications or operations used for the purpose of curing it." This is a fine distinction and it has been held that to exonerate the assailant the treatment must be *grossly improper.* If the wounds were not fatal but by unskilful treatment death ensued the assailant is not culpable. The refusal of the injured party to undergo treatment does not excuse the assailant as in R. *v.* Wall in which case the Lord Chief Baron charged the jury that no man was authorised to place another in so perilous a predicament as to make the preservation of his life depend on his own prudence. Even an abnormal position of organs or an unhealthy state of the body is no excuse, the most their presence can do is to reduce the capital offence to manslaughter for the Chief Baron remarked in the case of Bennet *v.* Gedley that a man was not bound to have his body in so sound and healthy a state as to warrant an unauthorised assault upon him. In all cases the mitigation of the offence will depend on a careful consideration of the entire circumstances of the case.

WOUNDS.

Legal Definition.—According to the Statute (24 and 25 Vict., c. 100, sec. 18), the word "wound" includes incised, punctured, lacerated, contused, and gunshot wounds. But to constitute a wound within the meaning of the Statute, the *whole skin*, not the mere *cuticle*, or upper skin, must be divided (R *v.* M'Laughlin, 8 C. and P. 635). But a division of the *internal* skin, *e.g.*, within the cheek or lip, is sufficient to constitute a wound within the Statute (R. *v.* Warman, 1 Den. C. C. 183). If the skin be broken, the nature of the instrument with which the injury is inflicted is immaterial, for the present Statute extends to wounding, etc., "*by any means whatsoever.*" A wound from a kick with a boot is within the Statute (R. *v.* Briggs, 1 Mood C.C. 318).

Injuries, burns, and scalds—which, in accordance with the above definition of a wound, are not wounds—are provided for under the clause, "or cause any grievous bodily harm to any person."

Casper defines "an injury" to be "every alteration of the structure or function of any part of the body produced by any external cause." Taylor proposed the following as the best definition which can be given to the word "wound," whether in a medical or legal sense, viz., that it is "a breach of continuity in the structures of the body, whether external or internal, suddenly occasioned by mechanical violence." This would include dislocations, fractures, either simple or compound, injury to the skin or mucous membrane, and to internal organs. Burns and injuries due to the action of corrosives are excluded from the category of wounds.

Concerning Wounds in general.—Great care must be taken to ascertain the exact site and course of the injury on the body, as this precaution will greatly assist in answering the questions :—*Is the wound dangerous to life? Does it cause grievous bodily harm? Is it suicidal, that is, inflicted by the person on himself; or homicidal, inflicted by another?* The solution of the question of the dangerous character of the wound is left to the professional knowledge of the witness, who may be required to state his reasons for considering the wound dangerous to life. His mere assertion will not be accepted. "The safest course," says Elwell, "for the witness, in regard to all these questions, is to give a true and plain account of the wound, describing it minutely, and the probable consequences that may attend it." As a general rule, only those wounds in which the danger to life is *imminent* should be stated as dangerous to life. Compound fracture of the bones of the cranium, injury to any large arterial trunk, or to any of the internal organs, may be considered as "dangerous to life;" but where the danger is more

remote, as in the probable supervention of tetanus, erysipelas, etc., the medical opinion must be more guarded. But the medical witness should always bear in mind that death may follow the slightest injury. A case is recorded of death in forty-eight hours after extraction of a tooth. The contrary also holds good, for the most fearful injuries have been followed with recovery.

The following suggestions may help the practitioner in the formation of his opinion as to the probable danger of a wound :—

1. The extent of the injury. 2. The character of the instrument used in the infliction of the wound. 3. The violence suffered by the parts. 4. The size and importance of the blood-vessels and nerves injured. 5. Is the wound healing or likely to heal well, and is the constitutional disturbance severe or slight? 6. Age of the sufferer. 7. Is there any constitutional taint likely to render even a slight wound more severe, or even dangerous to life? 8. Has the previous medical treatment been skilful or otherwise?

Should the injured party be found dead, a careful *post-mortem* examination will alone determine the probable part the injury bore to the production of the fatal result. Wounds may prove fatal—

1. *Directly*—(*a*) Hæmorrhage; (*b*) Shock; (*c*) Mechanical injury.

2. *Indirectly*—(*a*) Erysipelas; (*b*) Tetanus; (*c*) Pyæmia or Septicæmia; (*d*) Gangrene; (*e*) Surgical operations.

3. *Malum Regimen*—(*a*) On the part of the patient; (*b*) on the part of the medical attendant.

As the condition of a fracture of the bone of a limb may become a question of considerable importance in medico-legal investigations the following brief account of the process of repair in fractures is given :—

From the First to the Third Day.—The period of inflammation and exudation. Ordinary signs of inflammation and laceration of the parts. Blood will be found extravasated round the fracture, also in the medullary canal mixed up with the fat.

From the Third to the Fourteenth Day.—Gradual subsidence of inflammatory action and growth of the soft provisional callus from the periosteum and surrounding structures, and internally in the medulla, forming a fusiform mass holding the broken ends of the

bones together with some degree of firmness. This becomes firmer and almost cartilaginous in density. When the bones are kept immovable, or are impacted, the provisional callus may not be formed. In the case of the ribs the provisional callus is always formed and Dupuytren's "ring of provisional callus" is constant. This may also occur in fractures of the clavicle.

From the Fourteenth Day to the Fifth Week.—Ossification of the provisional callus. The bone is first soft and spongy till the conversion of the soft callus is complete.

From the Fifth Week to some Months after the Injury.—Complete bony union of the fracture and absorption of the provisional callus.

The blood clot although it completely disappears from the immediate neighbourhood of the fracture at an early period, yet layers of dark coagulum may often be found beneath the superficial fascia for four weeks or more after the accident (Erichsen).

It may be of importance to remember this in medico-legal enquiries. The presence or absence of the signs of vital reaction will help to distinguish fractures caused before or after death.

Injuries to the Head.—These may be either *external*, affecting the integuments; or *internal*, affecting the brain substance, etc. In the latter, as a rule, there are signs of external violence. An ecchymosed tumour of the scalp may impart a *sensation of crepitation* to the finger, and may thus be mistaken for a fracture of the skull. The tumour may also pulsate if any large vessel be near it, giving one the idea that the pulsations are due to the movements of the brain. A large wound without fracture points to a more or less oblique blow, a small wound to direct violence. A blow with a heavy blunt weapon may make a clean incised wound, and often in these cases the seat of the bruise does not correspond with the centre of the cut. Dr Ogston mentions the case of a young lady where a cricket ball inflicted a wound across the forehead, immediately above, and of the length of, one of the eyebrows, which he could not distinguish from a wound by a cutting instrument. All injuries to the head are more or less severe and dangerous, and

great care is required in forming a prognosis with regard to the ultimate effect of an injury to the head. Inflammation of the brain does not, as a rule, supervene for about a week after the accident, and patients should not be considered safe from danger till two or three weeks after. Be it remembered also that in some cases the inflammatory action may proceed insidiously for some months without giving any distinct evidence of its presence till close upon a fatal termination. Scalp wounds are dangerous, from erysipelas, etc. They should be examined as to their extent, form, depth, and position.

Concussion of the brain may arise from falls on the nates, or from blows on the head. The face becomes pale, the pupils contracted, the pulse weak and small, the extremities cold, the respiration scarcely perceptible, and the sphincters relaxed. The tendency to death is from syncope. Reaction may then occur: the pulse quickens; the skin is hot and dry; there is great confusion of thought, from which the patient ultimately recovers; vomiting is present in most cases. Concussion often passes into compression, due to hæmorrhage from the lacerated cerebral vessels. Concussion and compression differ in this: in the former, the effects are instantaneous; in the latter, a short time elapses before the symptoms make their appearance; and these become more and more marked, whereas in concussion they gradually pass off. It is often a difficult matter to distinguish the effects of compression from those common to drunkenness or narcotic poisoning. The odour of the breath and the history of the case will assist in forming an opinion. Concussion of the brain may prove fatal without either fracture of the skull, effusion of blood within the cranium, or any other change being observed on dissection, death being caused by the shock given to the whole nervous organ, which, being unrelieved, speedily lapses into annihilation of function (Watson and Travers).

The symptoms of compression—a full, strong, and often irregular pulse; normal heat of surface; muscular relaxation; dilatation of the pupils; stertorous breathing, and paralysis, are not unfrequently retarded, and this consideration should render the opinion very guarded. Bryant records a case ("Surgery," vol. i., p. 216) in which a man was thrown out of a gig on to his head. After a short period of insensibility he walked for half-an-hour, and then gradually again became insensible, and ultimately died. A large clot was found over the left cerebral hemisphere, the blood evidently having flowed from the middle meningeal artery. The short period of insensibility probably arrested the flow of blood from the artery, which recurred on the sufferer walking. The structural form of the cranium may have much to do with the danger to be expected from blows—some skulls being thinner than others—and in a few rare instances the fontanelles may not have become ossified during life.

The possibility of an unhealthy condition—atheroma—of the arteries of the brain, or of disease of the heart, must be taken into consideration before venturing an opinion as to the tendency or ultimate cause of death.

It may be stated that the patient died of apoplexy. Apoplexy is a disease of old age, and seldom occurs in the young, although it is just possible it *might* occur. The arteries should, in every case, be examined for the presence or absence of disease. When violence is used, the effusion of blood is, as a general rule, on *the surface* of the brain; but two cases are given by Dr Abercrombie of spontaneous bursting of a blood-vessel within the head, followed by effusion of blood *upon the surface* of the brain. "An external injury, co-existing with an extravasation of blood into the cerebral substance, does not necessarily imply cause and effect. The previous condition of the brain, or the outpouring of blood from diseased vessels, may, in fact, have been the cause of the accident" (Hewett). When, however,

blood is found effused on the surface of the brain, especially between the dura mater and the skull, either beneath or opposite to an external wound, we may reasonably infer that the hæmorrhage is due to a direct blow. Hæmorrhage so severe as to produce dangerous pressure on the brain, as a rule, comes from a rupture of the middle meningeal artery (ABERNETHY, BRODIE).

Some winters ago I saw a case in the Edinburgh Infirmary in which there was a large clot over the left frontal lobes, accompanied with aphasia and right hemiplegia, with no rupture of the middle meningeal artery, or any signs of external injury. The man had just left the cells on a charge of drunkenness. The source of the hæmorrhage was not clearly made out, but it seemed to be due to the rupture of an artery in a pachymeningitic patch. Blood may be found in the cavity of the arachnoid in the great majority of severe injuries to the head, and even in trifling cases where least expected. The effused blood may, after a time, become changed, and form a false membrane on the *parietal* arachnoid, seldom on the *visceral* surface. Blood cysts may even be formed, in the course of time, having all the appearances of a serous membrane. The blood may spread to parts remote from the seat of injury, and the extravasation does not always occur at the exact spot of the application of the blow, but often at a spot directly opposite. Two extravasations may be the result of one blow.

Fits of passion have been pleaded as a cause of apoplexy, but this cause is rare. Fracture of the cranial bones may be due to counter-stroke—*contre-coup*—or to falls on the nates, etc. Fissures of the base of the skull are always transverse. Punctured wounds of the cranium are always dangerous, but the patient may survive many days. The writer was once called in to see a boy shortly after he had been kicked by a pony in the region of the left temple, and although a small portion of brain substance was squeezed out through

the wound, the boy recovered without a bad symptom. Dr Bigelow, Professor of Surgery in Harvard University, U.S.A., relates a case in which an iron bar, weighing thirteen and a quarter pounds, three feet seven inches in length, and one inch thick, was driven through the head, followed by recovery, the patient only losing the use of the injured eye.

For the detection of brain substance on weapons the microscope is alone reliable, and then only the tubular portion of the brain is of any use.

Injuries to the spinal cord may cause immediate death; cases, however, occur of life being prolonged for some days, or even longer, after injury to the cord. The symptoms are progressive paraplegia and paralysis of the bladder and rectum, ending in death. Spicula of bone in the cord, dislocation of the vertebræ, or extravasation of blood in the membranes of the cord, may be found after death. The presence of blood upon the spinal cord is not necessarily the result of violence, as Dr Abercrombie has shown that hæmorrhage may take place spontaneously. The spine should be examined in all fatal cases of supposed injury. Concussion of the spinal cord is a fertile source of differences of opinion in railway cases. In no case should a hasty decision be given as to the probable future result to the patient from the injury.

Wounds of the *face* are not generally dangerous, unless they penetrate the brain.

Wounds of the *throat* are more or less dangerous, due to the possibility of severe hæmorrhage, emphysema, and bronchitis.

Wounds of the *chest* are dangerous, on account of the amount of the hæmorrhage which may take place, and the importance of the organs which may be injured. Death may result more from the mechanical action of the blood effused than from the depressing effect of the quantity evacuated. A fracture of the ribs may give

rise to injury of the lung substance or to inflammation of its coverings. The ventricles of the heart may be pierced, and yet life may be prolonged for one or two months, permitting of considerable locomotion during that period (Briand et Chaudé Med. Leg., vol. 1, p. 511). It is often difficult to make out the direction of the wound, as the lungs change their position during respiration.

Wounds of the *abdomen*, penetrating the intestines, although not necessarily fatal, may cause death from peritonitis, due to the escape of the intestinal fluids. Hernia may also follow wounds of the abdomen. Rupture of the liver is not of infrequent occurrence, and may occur without any external sign of the injury. The rupture is, as a rule, longitudinal, transverse lacerations being rare. The cœliac plexus may be much damaged by a blow or kick on the stomach, especially if this organ be distended with food, and death may result, without leaving any trace of the injury externally or internally. The bladder may be ruptured and death result from extravasated urine. Coagulable lymph, the effect of a wound of a serous membrane, may be thrown out in twelve hours or less.

Injuries to the abdomen may cause death by—

1. Shock ; without lesion of the internal organs, inflammation, or external signs of injury.
2. Hæmorrhage.
3. Lesion of the internal organs, but without inflammation. Death in these cases seems to be due to depression of the nervous system due to the intense pain following these injuries.
4. By inflammation without lesion of internal organs.
5. Inflammation from lesion of internal organs.
6. Destruction of the natural functions of the organs, and, as a result, malnutrition of the body.

Except in the first case, when death is instantaneous, wounds of the abdomen are not as a rule immediately fatal.

Wounds of the *genital organs* of the female may cause fatal hæmorrhage, which takes place from the

plexus of veins which, in these parts, are devoid of valves. A kick from behind whilst the woman is stooping or kneeling may rupture the labial vessels, and death supervene.

An important question here arises before we consider the characters of the several kinds of wounds. Have the wounds found on the body been produced during life or after death? The answer is beset with difficulties, and considerable caution will be necessary, but Tables will be given under the different kinds of wounds to assist the diagnosis. Signs of vital reaction are important, as showing the *ante-mortem* infliction of the wound; but these may, to some extent, be removed by the action of water, as in cases where the body is found in a pond. Under these circumstances the evident signs of drowning—water in the stomach, etc.,—will assist the diagnosis. The presence of putrefaction also greatly obscures the diagnosis. The presence of coagulated blood between the edges of the wound is not a trustworthy indication of the *ante-mortem* infliction of the wound, as experiment has shown that as long as the body remains warm coagulation may take place. Coagu lation even in contused wounds, effected before death, may be retarded from various unknown causes—disease, *e.g.*, scurvy; mode of death. *e.g.*, asphyxia. The amount of hæmorrhage on or around the body is, other things being equal, a safe criterion as to the time when the wound was inflicted A considerable amount of arterial blood points to *ante-mortem* injury; the presence of venous blood to *post-mortem* injury.

Duties of a medical man when called to examine a wounded person.—The surgeon should at once visit the wounded party, and proceed to examine the injury, for if this be done before swelling occurs, he will be better able to form an opinion of its nature, extent, and severity. If the wound has been dressed, he should, if possible, obtain the attendance of the person who

applied the dressings, and who would be able to describe their nature, and the dangers to be avoided in their removal, should that be deemed necessary. In no case should a surgeon remove the dressings applied by a professional brother without his presence and assistance. The condition of the injured party should be carefully noted, and a minute description of the wound written down at the time. The statements of the bystanders are also useful, and should be noted (see page 24).

Dying Declarations.—The principle on which these are accepted is founded partly on the awful situation of the dying person, and partly on the absence of interested motives in one on the brink of a terrible eternity, and which is supposed to obviate the necessity of a cross-examination. Unfortunately the annals of criminal jurisprudence are not free from lamentable instances of the hollowness of the above assumptions,—see the dying instructions of David to his son Solomon, and the writings of Mr Amos and others on the subject. The greatest care must be taken by the medical man who is called in to see a person supposed to be dying, with regard to any declaration he or she may wish to make. The medical attendant should simply take the statement as it is made, writing it down on the spot, or as soon after as possible. The identical words used should be committed to paper, and no suggestions or interpretations of his should be made. Leading questions should *never* be put, or any attempt made to induce the patient to make any statement. When we consider the condition of the patient, the possibility of delirium induced by the severity of the injury, together with the dread of death, it is, to say the least, injudicious to introduce the suspected party into the room for the purpose of identification, though this procedure has been suggested by some writers. In every case, however, it is advisable for the medical attendant, as soon as he sees that the case must end fatally, to acquaint the patient

in the presence of others of the fact, when any statements made may then be taken. Such statements are preferably best made before a magistrate if time will allow. It should also be borne in mind by those receiving dying declarations, that in England "it must be shown that the deceased, at the time he made the statement, was under the impression that death was impending; not merely that he had received an injury from which death must ensue, but that, as the popular phrase goes, "he then believed he was on the point of death" (R. *v.* Forester). In one case (R. *v.* Fagent, 7 C. & P., 238), it was held that a declaration was inadmissible, because the person making it asked some one near her whether he thought she would "rise again;" and it was held that this showed such a hope of recovery as rendered the previous declaration inadmissible. The declaration should be signed by the person making it, and witnessed by some one present at the time. The validity of a dying declaration has been called in question when made by a person who has suffered a severe concussion of the brain, and then recovered his sensibility. It is well known that under such circumstances the recollection of what took place before or after the injury is in many cases very imperfect, and the injured party may thus draw unintentionally upon his imagination for his facts. In Scotland, "the written deposition of a person who is dead is admissible, whether the person were the party injured or not, if he would have been a competent witness. It is not necessary that the deceased believe himself to be dying when he emits the deposition, for his consciousness of approaching death may be inferred from the nature of the wound, or the state of illness or other circumstances of the case. Such depositions are generally taken by a magistrate, but a declaration deliberately made, though without an oath, and taken down 'by a creditable person,' is admissible" (MACDONALD, "Scottish Criminal Law," page 512).

Is the Wound Suicidal or Homicidal?—In cases of suicide, punctured, incised, and gunshot wounds are more frequently present, seldom contused wounds, unless the person threw himself from a height. Very large wounds are seldom suicidal. It is important to note the direction of a wound, in order to show whether it was caused by a fall on the weapon or not. Wounds made by suicides are generally over vital parts, and a multiplicity of wounds does not point to suicide, except in maniacs, or in very old people where the skin hangs in folds about the neck. Gunshot wounds, when suicidal, are generally found over the region of the heart, temple, or in the mouth. Presence of scorching and powder-marks are important, as pointing to the probable distance at which the firearm was discharged; but their absence is no proof that the weapon was not discharged close to the body. The presence of the weapon being close to the body affords a presumption as to the possibility of suicide—its absence, the probability of homicide; but the weapon may be stolen from the side of the suicide. The hands should be examined for marks suggesting the probability of suicide; contusion or abrasion of the fingers from the recoil of the pistol held unsteadily. It may be suggested that the weapon was placed in the hand by the murderer, and that contraction, the result of the *rigor mortis*, had retained it. This is a fallacy, as it has been proved that, even when the weapon has been placed in the hand prior to the accession of the *rigor mortis*, and there kept by bandages, it can be removed with ease. This is not the case, however, when the retention of the weapon is due to spasm immediately preceding death. It is strong evidence in favour of suicide if the gun or pistol have burst by the explosion, as suicides have a predilection for overloading the weapon employed. The oldness, uselessness, or the novelty—old gun barrel—of the weapon used, points also to suicide.

Pretended Assault.—How may wounds, alleged to have been the result of an assault, be shown to have been self-inflicted?

By considering—

1. *The Character of the Wounds.*—In these cases the wounds are generally slight, and may consist in a series of small superficial wounds.

2. *The Parts of the Body where they are, and those where they are not.*—They are never found on vital parts, but always where there is little danger of doing much harm.

3. *The Clothes of the Person pretending to have been assaulted.*—The cuts in the clothes do not, as a rule, correspond with those on the body; for instance, a long cut in the coat, and a short one in the body, or *vice versa.*

Points of Importance to be noticed in Examination of a Dead Body found Wounded.

1. Note situation, extent, depth, breadth, length, and direction of wound. Take careful measurements, in order to determine the character of the weapon, and the organs of the body injured.

2. Is there any appearance of ecchymosis, or is the effused blood liquid or coagulated?

3. Examine wound as to presence of pus, adhesive inflammation, gangrene, or foreign bodies.

Why? Presence of pus, etc., will show that death must have taken place some time after the wound was inflicted.

4. In all examinations of wounds, be careful to disturb as little as possible their outward appearance, in order to compare the wound with the suspected weapon.

5. All notes should be taken during such examination, or *immediately* after.

6. Make a careful examination of all the important organs of the body.

Why? In order to disprove the suggestion that death was due to other causes—poison, disease, etc. This is important, as in the case of a girl who, dreading a whipping, swallowed some arsenic from which she died, yet her father was tried for causing her death by the severity of his punishment.

7. Only facts should be stated in the Report; *no inferences* should be drawn or suggested.

8. In describing the appearance of wounds use *simple untechnical language,* and avoid superlatives and high-flown words to

describe and explain simple facts. Fuller says—"To clothe low grovelling matter in high-flown language is not fine fancy but flat foolery."

9. In gunshot wounds, note position of body, state and contents of the hands, and the direction of the wound in relation to external objects.

Note also in all kinds of wounds the relationship of the wound to cuts or rents in the clothes of the deceased.

THE SEVERAL KINDS OF WOUNDS.

(1) Incised; (2) Punctured; (3) Lacerated and Contused; and (4) Gunshot.

1. INCISED WOUNDS.

Made by sharp instruments.

General Characters.—Incised wounds are somewhat spindle-shaped, their superficial extent being greater than their depth; the edges are smooth and slightly everted, and always larger than the weapon which inflicted them—due to retraction of the divided tissues. If a wound be in a line with the fibres of a muscle, there will be less "gaping" than when the wound is directly or obliquely across the muscle. Due to muscular contraction, or the elasticity of the skin, an incised wound may assume a crescentic form. The cellular tissue is infiltrated with blood, and coagula are found at the bottom and between the lips of the cut. It must be borne in mind that a wound with smooth edges may be made by a *blunt* weapon over bones near the surface, as on the scalp and over the tibia or shin, but a certain amount of contusion may, in most cases, be detected by careful inspection a short time after the receipt of the injury. Remember the case before mentioned of an incised wound made by a cricket ball.

It is often of importance to distinguish where the weapon entered, and where it was drawn out. The end

where the weapon entered is usually more abrupt than the other, which is naturally more drawn out. But in some cases I have seen, where the weapon was simply drawn across the part, both ends of the wound were alike.

Danger of Life from Wounds.—In the case of incised wounds the danger is due to hæmorrhage; to internal hæmorrhage, the result of injury to a large vessel; or to suppuration and formation of an abscess in punctured wounds; to destruction of the parts followed with exhausting suppuration and gangrene in lacerated wounds.

Death from Hæmorrhage.—The surface of the body, lips, and gums, are pale and exsanguine. The venous trunks, lungs, and other organs contain but little blood, but the veins of the *pia mater* are generally not emptied. Hypostasis, both external and internal, occurs on dependent parts of the body. Blood is found round the body, unless the hæmorrhage has been internal. It is often impossible to detect the particular vessels from which the blood has flowed; but this is not of much importance. The signs of death from this cause may be rendered obscure by putrefaction; but if nothing be found to account for death but the presence of a wound, we must conclude that death has been caused by it.

2. PUNCTURED WOUNDS.

The orifice is generally a little smaller than the weapon. A stab may sometimes present the appearance of an incised wound; the depth will, however, help to distinguish the one from the other. The wound may not at all correspond with the shape of the weapon, and the same pointed instrument may produce very different-shaped wounds in different parts of the body. On dissection, two or more punctures may be found in the soft parts, with only one external orifice; these are due to the weapon being only partially withdrawn at each stab. Punctured wounds are always

more dangerous than incised. They cause little, if any, hæmorrhage externally, unless a large vessel, such as the femoral artery, be injured. These wounds generally heal by suppuration, and not infrequently an abscess is formed in and around the track of the wound. Perforating wounds generally have a large entrance wound with inverted edges, and a small exit with everted edges; if the weapon be rough, the reverse may be the case.

3. LACERATED AND CONTUSED WOUNDS.

The edges of these wounds are never smooth, and generally do not correspond at all with the weapon. A considerable amount of contusion or bruising surrounds the solution of continuity of the part. Hæmorrhage from these wounds is usually slight. A point of considerable interest may arise in connection with this class of wounds; the defence may declare that the injury was the result of a fall, and not due to a blow. The history of the case, and the presence of a bruise where no theory of a fall can explain its existence, will often afford the only solution of the difficulty. Lacerated wounds heal by suppuration, generally with more or less sloughing. Scratches with the finger nails may be considered as lacerated wounds, but the skin is merely abraded, not divided. They are never important as wounds, but often as a proof of a struggle in cases of rape, etc. Bites are also lacerated wounds. The diagnosis of lacerated and punctured wounds, whether inflicted before or after death, will depend on much the same grounds as those of incised wounds, hæmorrhage, vital reaction, etc.

The following TABLES, as aids to Diagnosis, are given by WOODMAN and TIDY :—

INCISED WOUNDS.

IN THE LIVING.	IN THE DEAD.
1. Edges sharply cut and everted, the skin and muscles being retracted.	1. Edges close, and not everted.
2. Bleeding copious, and generally arterial.	2. Bleeding absent or scanty.
3. There are clots.	3. There are no clots in most cases; sometimes a few strial clots.
4. There is a good deal of staining or diffusion of blood in the muscular and connective tissues.	4. There is little or no staining or diffusion of blood in the tissues of the wound.
5. After some hours or days there will be signs of repair or inflammation.	5. There will be no attempt at repair, and no signs of inflammation. There may be signs of putrefaction.

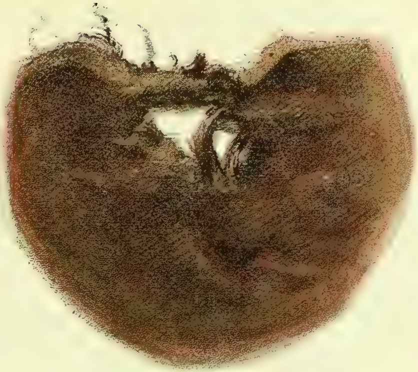
CONTUSED WOUNDS.

IN THE LIVING.	IN THE DEAD.
1. There is swelling and, after a few hours or a few days, if deep-seated, the skin changes colour, particularly at the edges.	1. There is little swelling or change of colour.
2. There is effusion of liquid blood and lymph in the deeper parts, and coagular form.	2. Very little blood is effused. There are hardly any clots.
3. The swelling subsides and the colours fade after some days, or, in some cases, weeks.	3. There are no rainbow-like or prismatic changes of colour.
4. Abscesses may form, or ulceration, sloughing, or erysipelas set in.	4. No abscesses form, and no erysipelas or dangerous changes are met with.

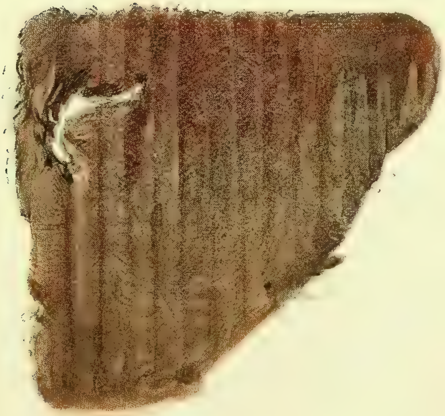
LACERATED WOUNDS.

IN THE LIVING.	IN THE DEAD.
1. There will be more hæmorrhage and staining from the blood at first.	1. There is hardly any hæmorrhage or staining unless large veins are torn across.
2. After a few hours, or days, there will be suppuration or other sign of repair; inflammation or gangrene may also supervene as in incised wounds.	2. No evidence of repair, or inflammation, or gangrene can be detected.

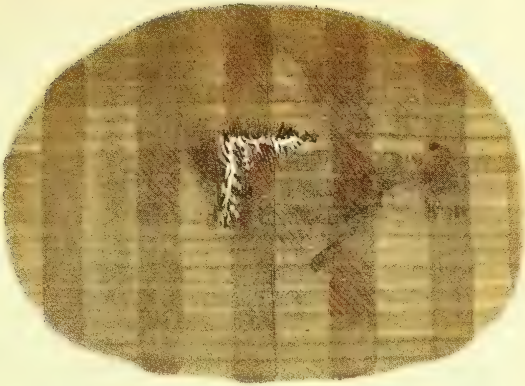
4. Gunshot Wounds.—The appearance which gunshot wounds present will to a great extent depend upon the form of the projectile, and the distance at which the firearm was discharged. Round balls make a larger opening than conical. Small shot, fired within a short distance of the body, make one large ragged opening. The scattering of the shot depends on the calibre of the gun, on the charge of powder, and essentially on the distance. A charge of ordinary (No 5) shot, to make a single hole, must have been fired at less than *one foot;* but experiments should always be made with the alleged weapon. A patent cartridge would make a single hole at a considerable distance—five or six yards. Round bullets may split, but the conical ones seldom do. The edges of wounds produced by the discharge of firearms are always more or less ecchymosed; this condition appears in about an hour after the infliction of the injury. If the ball strikes obliquely, the edges of the wound may be much lacerated, or the opening may be valvular and of small size, if the skin over the part be in any way tightened, or if a conical ball has been used. The injury to bones is greater from conical than from round balls The old round balls were easily deflected; the conical are not so easily turned aside. The track of the ball *widens as it deepens.* This is the reverse of an ordinary punctured wound. The ball may either lodge in a part, or perforate it. Should it have lodged, it must be preserved and compared with the alleged firearm. Bits of clothing or wadding may be carried into the wound. The latter should be carefully kept, as they may prove important as a means of identification. The aperture of entrance and exit must, if possible, be determined. On this point there is much difference of opinion. The wound of *exit* is always *smaller* than the wound of *entrance* (Casper). In this opinion Casper agrees with M. Malle, Ollivier d'Angers, and M. Huguier, but is opposed by Taylor, M. Matthysens, and others. "The characters of a



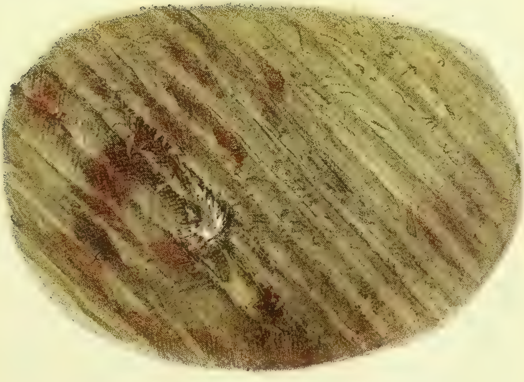
Entrance Wound in Vest.



Entrance Wound in Under Vest.



Exit Wound in Shirt.



Exit Wound in Under Vest.

gunshot wound," says Assistant-Surgeon Neill, "are those of a contusion and laceration of all the tissues. Sometimes they are so simple as to bear resemblance to a punctured wound, particularly if a rifle-ball (conoidal), revolving on its long axis, has passed through the soft parts at a great speed, but within a few hours it resembles a contusion. The wound of entrance, as it has been termed, bears no comparison in size or shape to that of the exit when a rifle ball has caused the injury. In the former you see the edges of the wound curving inwards, and the circumference small, with little or no hæmorrhage. In the latter, the wound is large, with torn and irregular edges projecting outwards, and perhaps only slight oözing of blood. In a short time, averaging an hour, round the entrance wound slight redness begins, gradually extending to about two inches round its orifice. Again, this colour changes to a blue or greenish black, and you see all the appearances of a severe bruise, with a small wound of the skin, its edges still curved inwards. In the exit wound the discolouration of the skin is not apparent." The probable reason for the discrepancies in the statements of observers, as to the characters of entrance and exit wounds, may be found in the fact that experiments have been conducted with different-sized balls, different kinds of weapons, with varying quantities and qualities of the powder used, the character of the wads, and with varying velocities and distances. As pointed out by M. Roux, the two openings may be equal if the ball preserves the same velocity through the tissues as it possessed before entrance; the *entrance* hole is smaller than the *exit*, when the ball has lost much of its trajectile force, and enters the softer parts of the body first; the *entrance* is larger than the *exit*, when the ball first enters through the denser tissues of the body, and leaves through the softer. Just as these pages were on the point of being sent to the printers, an accident occurred of which the following is an

account:—A farmer, whilst sitting in a boat, was in the act of moving a muzzle-loading rifle to make room for his dog, when the weapon was accidentally discharged. The bullet, a round one, half-an-inch in diameter, entered the left axilla and passed out midway between the spinal column and the right border of the left scapula. On moving the arm from the body, a round hole the size of a shilling, opening into a dark cavity, was found at the top of the axilla, and on turning the body over, a small triangular slit was found with no eversion of the edges. In fact, I had to search for the exit wound. The muzzle of the rifle must have been somewhat less than the length of the arm from the point the bullet entered. The relative size of the holes in the clothes corresponded with those in the body. The brother of the deceased, who drove me home, and who was present when I examined the body, voluntarily remarked that had he not known how the accident occurred, he would have sworn that his brother had been shot from the back; for in shooting animals, pigs, etc., he had noticed that the wound of exit was always larger than the wound of entrance. This case goes to prove the statement of Casper, whose experience was obtained from the results of point blank firing on barricades at probably similar distances as that in the case of the farmer just mentioned. The opening of entrance made by the ball has generally, but by no means always, inverted edges. The edges of the exit opening are everted, bloody, and raw; but both the entrance and exit wounds may be everted in fat persons, due to the protrusion of the fat; and this eversion may also result from the expansive power of the gases generated during putrefaction, should this condition be present. Wounds made by *double shots*, as from double-barrelled guns, or pistols, or from slugs fired from one barrel, diverge after their entrance into the body.

In the examination of gunshot wounds we have to consider—

1. *Direction in which the Gun was fired.*—The track and position of the ball in the body, coupled with the relative position of the body to a window or door through which the gun may have been discharged, and the place where the ball is found, should it have passed through the body, may assist us in forming an opinion. It is often impossible to trace the course of the ball through the cavities of the body, but through the muscles and denser structures this is more easily accomplished. The effects of the ball on surrounding objects may assist very much in finding the direction of its course. Sir Artley Cooper by a careful consideration of the above suggestions once correctly determined that a left-handed man had fired the fatal shot.

2. *Distance at which the Charge was fired.*—In the case of wounds inflicted by small shot, the scattering of the shot must be our guide. Dupuytren has related a case in which a fowling-piece charged with powder alone and fired at a distance of two or three feet from the abdomen made a round hole in the belly and killed the man. The absence of scorching, or marks made round the wound by the half-burnt powder, allows of the assumption that the shot must have come from some distance—rather more than four feet. The absence of any of the above, however, is not an absolute proof that the shot has come from a distance.

There is no means of deciding, from an examination of a pistol or gun, when the weapon was last used. In all cases medical men, unless sportsmen and familiar with firearms, should hand over the weapon to a gamekeeper or gunsmith, and not attempt to give an opinion on matters about which they know nothing. The following may be of use to students for examination purposes, but for nothing else:—Among the products formed when gunpowder is exploded is the sulphide of

potassium, but if exposed to the air some portion of this substance is converted into the sulphate of potash. If, then, the gun-barrel be washed out with distilled water, and the washings filtered, and, on the addition of a solution of acetate of lead, a black precipitate of sulphide of lead be formed, this is supposed to point to recent use; if, on the other hand, a white precipitate of sulphate of lead forms, to the use of the weapon at some more distant date than the period alleged.

BLOOD-STAINS.

Blood-stains may have to be examined on clothes, on weapons, and on articles of furniture. The stains may be either *recent* or *old*; in either case, the method of identification is the same. There is not much difficulty in ascertaining whether a suspected colouration is due to blood or not; but when the question arises as to whether the blood be human or that of some other animal, the identification is in most cases impossible.

On weapons, the question may arise, Is the stain blood or rust? Heat the metal—the blood-stain will peel off; that due to rust will remain. But something more is necessary than this rough test. The stain, if large, may be scraped off and placed in some distilled water in a watch-glass, and the solution filtered, to separate any oxide of iron. The stain is *not* that of blood if the water thus treated does not acquire a red or reddish-brown colour. Another method is to moisten a piece of glass with water and lay the weapon on it in such a manner as to dissolve off the stain. A portion of the solutions thus obtained may be tested with tincture of guaiacum and peroxide of hydrogen for blood; ammonia for vegetable colours; and with ferrocyanide of potassium for iron. Stains of citrate of iron have been mistaken for blood-stains; the knowledge of this fact should prevent an opinion being given from a

mere ocular inspection of the stain. The stains of the citrate may thus be distinguished:—The filtered solution is yellowish, not red; ammonia produces no change of colour; guaiacum, a blue colour if a persalt of iron be present; confirmed by the production of Prussian blue on the addition of ferrocyanide of potassium to a portion of the original solution.

The method of procedure for the detection of blood may be as follows:—If the stain exists on cloth or linen, a strip of the stuff is cut off and suspended in some distilled water contained in a small test tube. Streaks of colouring matter will gradually appear descending from the cloth to the bottom of the tube, where a coloured layer will eventually be formed. If the stain be recent, the colour will be deep red; but if of older date, of a reddish-brown hue. If one strip of the stuff does not yield a solution of sufficient intensity of colour, other strips may be treated in a similar way till the requisite degree of intensity is obtained. In stains on wooden articles, a splinter may be cut off and treated as above.

The solution thus obtained may be divided into several portions, and treated as follows:—To one portion add a little dilute ammonia, when, if the colour present be due to blood, no other alteration than a *slight* heightening of the colour will take place. If, however, the colouration be of vegetable origin, the addition of the ammonia will change it to green, crimson, etc.

If another portion of the solution be carefully boiled, the colour will disappear with the formation of a dirty-brown precipitate. If this precipitate be boiled in liquor potassæ, a solution will be formed which is red by reflected, and green by transmitted light. Any stain which gives, when thus treated, the above reactions, is almost sure to have arisen from the presence of *blood.* A third portion, dropped on blotting paper, may be next treated with tincture of guaiacum and peroxide

of hydrogen, with the production of the characteristic blue colour if blood be present.

The *form* of the corpuscles should be noted. For this purpose a small quantity of the sediment should be removed by means of a pipette, placed on a glass slide, and examined under the microscope. The blood corpuscles will, of course, be always more or less shrivelled and disfigured, but their general appearance may be noted. The corpuscles of human blood are minute, round, flattened cells about $\frac{1}{3000}$ to $\frac{1}{4000}$ of an inch in diameter, slightly depressed, and concave in the centre, consisting of a colourless envelope containing a red fluid. The blood cells of birds are oval.

To obtain the corpuscles, if the stain has not been rubbed or washed, Roussin recommends the following procedure:—The portion of the cloth containing the stain is cut out and placed on a glass slide. On it is dropped, from a pipette, a mixture of three parts by weight of glycerine, one of sulphuric acid, and water, so that the mixture thus formed shall have a specific gravity of 1028. The material when thoroughly moistened is teased out, the fibres removed, and the fluid left on the slide. The blood corpuscles of all the mammalia are of the same shape and character, differing only to a slight degree in size. In birds, reptiles, and fishes, the blood-cells are more or less *oval* in form.

The stain, or a portion of the solution obtained, as before described, should be examined for crystals of hæmin. In order to procure them, the solution should be treated with a little glacial acetic acid, and then gently evaporated on a glass slide. If, on submitting the residue to microscopical examination, no crystals be observed, fresh acetic acid must be added, together with a minute quantity of common salt, and the solution again evaporated; in the event of this failing to produce them, the above process may be repeated a third or fourth time. The form of the crystals differs in the blood obtained from different animals. In man

the crystals are rhombic, of a dark red or yellowish red colour, frequently arranged in stellate groups, and are very uniform and characteristic.

The spectroscope has lately afforded valuable help in the identification of blood-stains. A solution of the colouring matter is placed in a narrow glass cell, and examined with the spectroscope, when the modifications in the spectrum noticed on page 92 will be seen.

Table recapitulating the Characters of Blood-Stains, under the following heads :—

1. *Ocular Inspection.*—Blood-stains on dark-coloured materials, which in daylight might be easily overlooked, may be readily detected by the use of artificial light, as that of a candle brought near the cloth. Blood-spots, when recent, are of a bright-red colour, if arterial; of a purple hue, if venous,—the latter becoming brighter on exposure to the air. After the lapse of a few hours, blood-stains assume a reddish-brown tint, which they maintain for years.

2. *Microscopic Demonstration.*—With the aid of the microscope, blood may be readily detected by the presence of the characteristic blood-cells; but even this means of diagnosis may be rendered impossible, by—

(*a*) The blood being long effused.
(*b*) The spot being wetted and then dried.
(*c*) The blood being mixed with other substances.
(*d*) The spot on the cloth having been much rubbed, or the cloth washed.

3. *Action of Water.*—Water has a wonderfully solvent action on blood, the stains rapidly dissolving when the material on which they occur is placed in cold water—a bright-red solution being formed. Rust is not soluble in water.

4. *Action of Heat.*—Blood-stains on knives, etc., may be readily removed by heating the metal, when the blood will peel off, at once distinguishing it from rust. Should, however, the blood-stain on the metal be long exposed to air, spots of rust may be mixed with the blood, when the test will fail. The solution of blood obtained in water is coagulated by heat, the colour entirely destroyed, and a flocculent, muddy-brown precipitate formed.

5. *Action of Caustic Potash.*—The solution of blood obtained in water is boiled, when a coagulum is formed, soluble in hot caustic potash; the solution so prepared is greenish by transmitted, and red by reflected light.

6. *Action of Nitric Acid.*—Nitric acid added to a portion of the solution of blood in water produces a whitish-grey precipitate.

7. *Action of Guaiacum.*—Tincture of *guaiacum* produces in a watery solution of blood a reddish-white precipitate of the resin; but on the addition of an ethereal solution of *peroxide of hydrogen*, a beautiful blue colour is almost immediately developed. This test is so delicate that one drop of blood in six ounces of water may be detected by it; and, according to Dr Taylor, is, with the spectroscope, the only certain method of discovering washed blood. Washed stains on colourless cloth may be detected by pouring a drop of the tincture of guaiacum on them, and then adding the peroxide of hydrogen. The tincture of guaiacum should be made from fresh resin, and preserved in the dark. The peroxide of hydrogen may be obtained under the name of ozonised ether. Other red colouring matters give a reddish colour to the precipitated resin, but the blue colour does not appear when treated with the peroxide of hydrogen, as above described, except after the lapse of some time, and this at once marks the absence of blood. Dr Ogston, however, states that he has obtained the blue colour with the guaiacum and peroxide of hydrogen from sweat stains.

8. *Hæmin Crystals.*—These are produced by treating a drop of blood, or a watery solution of it, with glacial acetic acid in a watch-glass, and then evaporating the mixture. The dried residue now contains the crystals of hæmin, which may then be examined under the microscope. The crystals are rhomboidal in form, tubular, or otherwise, of a yellowish, yellowish-red, or dirty blood-red colour. When the stain is old, a minute quantity of table salt should be added to the acetic acid solution of the colouring matter of the blood.

9. *Spectroscopic Appearances.*—Two dark absorption bands appear in the spectrum, one situated at the junction of the yellow with the green rays, and the other in the middle of green rays of the spectrum. These may, however, from various causes be modified. The spectrum of blood treated with carbonic oxide gas presents two similar bands to those of normal blood, but the red and violet rays are more completely absorbed. These bands also do not disappear under the influence of reducing agents, as is the case with normal blood. The spectrum of alkanet root in solution of alum is like that of recent blood, but differs in having a third absorption band between the green and the blue. In a solution of cochineal and ammonia, one black band obliterates the yellow and orange rays. This test requires care and considerable practice at spectrum analysis.

There is no means of detecting menstrual blood from human blood, the result of a wound.

BURNS AND SCALDS.

A *burn* is caused by the direct action of flame or the application of any highly heated substance to the surface of the body. A *scald* is due to the action of boiling water or other highly heated fluid on the body. Burns sometimes present little more than a slight redness of the skin, which may pass off in a few days; at other times blisters are formed, the base of the blister being red, with a narrow red line round it. Burns may result from only a slight application of heat, due probably to the thinness of the skin in some individuals. Often troublesome ulcers are formed, or the skin may be charred. On the same person the appearance of each burn may be different. The danger from burns depends more on the extent of surface injured than on the intensity of the burn. Burns of a half or a third part of the body must be regarded as fatal. They may prove fatal by shock, by asphyxia, by constant and profuse discharge from the burnt surface, and by secondary inflammations of internal organs, ending in some cases in perforation and peritonitis. Children are more affected by burns and scalds than adults—the simplest, in their case, often proving fatal. Persons have often been murdered, and then burnt in order to conceal the crime.

The following Table gives the different degrees of burns:—

1. Superficial inflammation, characterised by redness without blistering.
2. Acute inflammation, the epidermis raised forming vesicles containing serum.
3. Destruction of the superficial layer of the true skin.
4. Destruction of the skin and subcutaneous cellular tissue.
5. The superficial and deep parts converted into a charred mass.
6. Entire carbonisation of the parts.

(DUPUYTREN.)

Was the Burn Inflicted before or after Death?—Two characteristic appearances—redness and vesication—are present in burns inflicted during life, when the surface of the body is not charred and the tissues destroyed. The redness affects the surface and entire substance of the true skin, which is dotted by the deep red openings of the sudoriferous and sebaceous ducts. This appearance cannot be produced after death. Blisters are formed by a temperature somewhat less than that of boiling water. Vesication, according to Orfila, is characteristic of a burn inflicted during life; and the late Sir Robert Christison found that in burns caused before and after death the former contained serum, the latter air. In anasarcous subjects, however, serous blisters may be formed, especially if the heat employed be not too severe.

In burns produced after death, the surface and substance of the true skin is of a dull white colour, dotted with grey openings of the sudoriferous and sebaceous ducts, and the subcutaneous tissues are uninjected. In may be necessary to distinguish the vesicles due to a burn from the phlyctænæ, the result of advanced putrefaction. The vesications produced by a burn before death have a *purple-red line* at their circumference, and a more or less *red* base. Bullæ, the result of putrefaction, possess none of these characteristics. Their base does not differ in colour from that in the immediate neighbourhood of the vesicle. It appears possible to produce vesication by the application of intense heat after death; but these vesicles possess none of the appearances of vital reaction. The bullæ thus produced soon burst, and never, except in the cases before mentioned, contain serum, but only a thin watery vapour. The redness of the base, and the red bounding line round the circumference, so characteristic of a burn inflicted before death, are also absent.

Was the Burning Homicidal, Suicidal, or Accidental?—No general rules for guidance can be here laid down. In most cases, the conditions under which the body is found will point less to suicide than to homicide or accident. In cases of murder, the body is often burnt to destroy all traces of the crime. It must, however, be borne in mind that intense heat applied to the body may give rise to a wound on the surface like that caused by a cutting instrument. Casper mentions such a case, in which a wound was found over the liver, due to the application of intense heat to the body. The conjunction of robbery will greatly assist in helping to solve the difficulty. It may be very confidently stated that to dispose of a body by burning is no easy matter.

The possibility of "spontaneous combustion" is too absurd to be more than noticed here. It is only fair, however, to state that there are some medico-legal authorities who still believe in its possibility. Dr Ogston, who cautiously avoids committing himself to the belief in spontaneous combustion, yet thinks that the subject of preternatural combustibility in certain conditions of the body, may perhaps, to say the least of it, be set down as one still *sub judice.*

CONTUSIONS, BRUISES, ETC.

In the living these injuries are accompanied with swelling, pain, and more or less discolouration of the part affected. Among malingerers it is not an uncommon practice to bruise the body to imitate the spots of purpura and scurvy. In scurvy, the condition of the gums common to that disease, and the state of the general health, will point to the true nature of the spots. The diagnosis of purpura will be assisted by noting the diffusion of the spots over the body. In

old people purpuric spots frequently extend round the limbs, chiefly on one of the lower extremities. Some persons are very easily bruised, and a pinch, by no means severe, will cause on their arms a severe bruise. Discolouration — ecchymosis — may take place in the skin, cellular tissue, muscles, or internal organs as a result of external injury, or it may be due to sudden and powerful contraction of a muscle or group of muscles. Not infrequently the discolouration does not appear over the seat of injury, but at some distance from it; and when the effusion is deep-seated, days may elapse before any discolouration of the skin takes place, and then it is not blue, as in superficial parts, but of a violet, greenish, or yellowish hue. A deep-seated ecchymosis may give no external sign of its presence, hence in all cases deep incisions should be made before an opinion is ventured as to the entire absence of this occurrence. This is very noticeable among the deep-seated muscles of a limb. In these cases, forty or fifty days may elapse before the deep-seated bruise shows its existence on the surface, and then only as irregular, yellowish, green, or bluish spots over the part. A very slight contusion, as a sprain of the ankle, may give rise to extended discolouration up the leg. An ecchymosis is not necessarily situated directly under the seat of injury. A blow given during life may not appear as an ecchymosis till *after death.* The change of colour in bruises begins at the circumference, and travels inwards. During the first three days the colour of the bruise is blue, bluish-black, or black; greenish on the fifth or sixth day; and yellow from the seventh to the twelfth. The extent of an ecchymosis depends greatly on the looseness of the cellular tissue. A slight contusion causes a slight redness and swelling, and may leave no mark on the dead body, unless death has taken place within thirty-six hours. Injuries of this kind sometimes leave a parchment-like hardness and discolouration of the skin.

The part looks slightly depressed, due probably to the epidermis having been partly rubbed off, and the skin then drying. Similar marks are sometimes made by blisters. These marks may be produced on the dead body by friction and exposure to the air.

The diagnosis of ecchymosis from hypostasis has been given, see page 34. It appears also that a slight blow inflicted before death, would require a tolerably severe one after death to produce like appearances. In scourging, there are parallel ecchymosed lines, or small spots resembling petechiæ. An internal organ may be ruptured, and yet there may be no appearance of injury externally. The liver is most commonly ruptured. The rupture is almost always longitudinal, and in some cases a portion of the gland is more or less detached. The spleen is also not infrequently ruptured; and this occurs most frequently in countries where ague prevails. Rupture of the lungs and brain is rare. When the pelvis is fractured, the bladder is frequently found ruptured.

Death in most cases is due to internal hæmorrhage or shock, when any of the internal organs are ruptured.

Can the appearance of a bruise be produced after death? It is possible that the appearance of a bruise inflicted during life may be produced within two hours after death, and in some rare cases even after the lapse of three hours and a quarter; but these ecchymoses are limited in extent, and when large are due to a rupture in a vein which can be readily ascertained. The experiments of the late Sir Robert Christison, relating to this question, are detailed in the "Edinburgh Medical and Surgical Journal," vol 31. After reading the account of these experiments it seems to me that the amount of violence required after death to produce appearances like those made before death is such as would seldom, if ever, be inflicted on a corpse, and, therefore, where we find a well-marked bruise we ought to infer that it was made before death.

The following TABLE, compiled from the experiments of CHRISTISON, may assist the diagnosis:—

DURING LIFE.	AFTER DEATH.
1. Swelling of the part.	1. No swelling.
2. Coagulation of the blood effused into the adjacent cellular tissue, with or without tumefaction.	2. No such appearance, unless there is a rupture of a large vessel in the neighbourhood of loose cellular tissue.
3. Incorporation of blood with the whole thickness of the true skin, rendering it black instead of white.	3. No such sppearance produced by a blow after death.

N.B.—Extensive effusion may occur without affecting the skin, but when the skin is so affected Christison thought it decisive of *anti-mortem* injury.

The Size and Form of a Bruise should be noted.

Why?

1. *In Hanging and Strangulation.*—The mark due to pressure of the cord on the neck in hanging runs obliquely round the neck; in strangulation, the mark encircles the neck. The mark is frequently interrupted, and may present very varied appearances in different parts of the neck. The mark of the knot may be found under the chin.

2. *In Throttling.*—The pressure exerted on the throat of the deceased by the fingers of his assailant may leave marks which may point to the means used to cause death.

3. *In other Cases of Death by Violence.*—The impression made by the weapon used may lead to the identification of the murderer. The marks left by the wards of a large door-key once led to the identification of the assailant.

SUFFOCATION.

Death from suffocation is said to result from any impediment to the respiration which does not act by compressing the larynx or trachea.

Suffocation may therefore be caused by pressure on the chest, as in persons crushed in a crowd. It may also be due to the respiration of certain gases, or to the presence of pulverulent substances in the air, which act by choking up the air-passages. Imprisonment in any confined space may cause death from suffocation, and abscesses bursting into the trachea, or vomited matters in drunken persons lodging in the windpipe, may be attended with a like result. Pressure on the umbilical cord whilst the child is in the maternal passages causes death from suffocation.

Signs of Death by Suffocation.—The first effect of arrest to the passage of air into the lungs is the stagnation of blood in the capillaries of the lungs. Non-arterial blood then goes to the brain, and consciousness is soon lost. The respiratory sensation is then arrested by the circulation of venous blood. The left side of the heart becomes emptied, and then weak; the right side full and engorged. The great venous trunks are also more or less full, and the abdominal viscera, liver, spleen, and kidneys, congested. The arrest of the heart's action is a secondary effect; the right side is paralysed by being too full, the left by being empty. These signs may be said to be typical, or, rather, are to be expected in death due to suffocation, but it must be distinctly stated that they are not always present. The right side of the heart is not in all cases engorged with blood; and Christison warns medical men against expecting "strongly-marked appearances in every case of death from suffocation." The heart, moreover, continues to contract after the lungs have ceased to perform their duty. Death is thus due to apnœa—that is, death

beginning at the lungs,—and not to syncope. Death in some cases is from neuro-paralysis or nervous apoplexy. In death by shock, which in most cases is instantaneous, both sides of the heart are equally filled. Death, the result of disease, may present all the signs of death from suffocation, and no suspicion may be aroused as to the cause of death from the *post-mortem* appearances, especially if putrefaction have set in.

The following Table is given as an aid to diagnosis in this form of death :—

Points to be noticed in forming a Diagnosis of Death by Suffocation.

1. *The Blood.*—There is *unusual fluidity* of the blood found in death by suffocation, however produced. —This condition is sometimes present in deaths due to certain diseases, fevers, etc.; and in cases of narcotic poisoning. Even with the blood in this condition, the presence of coagula in the cavities of the heart is not infrequent. The colour of the blood is changed to a dark purple, but in suffocation by carbonic oxide it is red.

2. *Animal Heat.*—In persons who have died from suffocation the animal heat is long retained.

3. *Cadaveric Rigidity.*—Other things being equal, the *rigor mortis* is as well marked in this kind as in other forms of death.

4. *The Lungs.*—Hyperæmia of the lungs is rarely absent. In most cases both lungs are engorged in about equal proportions. Hypostasis—*post-mortem stains*—must not be mistaken for capillary engorgement.

5. *The Heart.*—Engorgement of the right side of the heart, the left being empty, or nearly so. It is advisable always to examine the heart first, and then the lungs. The pulmonary artery is also much congested.

6. *Capillary Ecchymoses.*—These appear as purplish-red spots on the pulmonary pluræ, on the surface of the heart, aorta, and even on the diaphragm. They may appear on the above-mentioned parts in a fœtus suffocated *in utero* by pressure on the cord. These ecchymoses are rarely seen on adults, most frequently on infants, due probably to the thinness of the coats of the capillaries, which are ruptured in the efforts made to breathe. They are not a positive sign of death from suffocation, as they have been seen in death due to cholera, typhus, and other diseases. They are present also where death is due to hanging, drowning, etc.

7. *Condition and Appearance of the Trachea.*—The mucous membrane of the trachea is injected, and appears of a cinnabar-red colour. This is present in every case of death by suffocation, and must not be confounded with the dirty cherry-red or brownish-red colouration due to putrefaction. Remember also that the trachea putrefies early. If suffocation be slowly produced, a quantity of frothy mucus may be found in the wind-pipe, and also in the smaller tubes of the lungs. Always examine, especially in cases of supposed infanticide, the trachea for foreign bodies, the presence of soot, etc. The presence of sand, ashes, etc., in the œsophagus and stomach in persons buried in these materials, is presumptive of the person having been placed in them prior to death.

8. *Kidneys, Vena Cava, etc.*—The quantity of blood in the kidneys is always considerable. The abdominal veins are all more or less congested, and the external surface of the intestines presents numerous traces of venous congestion.

9. *The Brain.*—Apoplexy of the brain, as secondary to the pulmonary apoplexy, may be more or less present, attended with its well-known appearances.

10. *Face, Tongue, and Mouth.*—The expression of the face is not characteristic of death by suffocation, and differs in no particular from that common to other forms of death, being more frequently pale than turgid; and the starting of the eyes, popularly ascribed to this form of death, is not often seen. The tongue may or may not be protruded beyond the teeth. The presence of *froth* about the mouth is not constant, and is of common occurrence in those dying from natural causes.

Was the suffocation homicidal, suicidal, or accidental?—Suffocation may occur accidentally during the act of swallowing, and by foreign bodies placed carelessly in the mouth, and then forced suddenly into the windpipe. Examine the lips for the presence of ecchymosis and other marks of violence. A man, some years ago, was accused of having caused the death of his wife by strangulation, for which he was indicted, and tried before the High Court of Justiciary in Scotland. The *post-mortem* examination revealed the cause of death as due to suffocation, and the following injuries were found on dividing the windpipe, which contained a quantity of frothy mucus: in the interior of the larynx there was a considerable extravasation of blood lying beneath the investing membrane,

and passing up on both sides and behind, as far as the chink of the glottis, or orifice by which air is admitted into the windpipe, and above that opening into the ventricles of the larynx. There was here, also, a fracture of the right wing of the thyroid cartilage, by which its lowest horn was wholly detached, and the cricoid cartilage was broken in two places at opposite sides of its ring. The defence was that she had fallen accidentally while in a state of drunkenness, and had thus produced the fatal injuries. The man was acquitted, the legal opinion in favour outweighing the medical opinion against the theory of accident. The above case created some discussion at the time, and induced Dr Keiller to make several experiments as to the possibility of fracturing the cartilages of the larynx. The following are his conclusions :—

1. That *ordinary* falls on the human larynx are apparently not capable of producing fractures of its cartilage, and even *falls from a height with superadded force* appear to be unlikely to do so.

2. That *severe pressure applied from before backwards,* so as strongly to compress the larynx against the vertebral column, or *violent blows inflicted over the larynx by means of a heavy body,* are sufficient to cause fractures of the larynx. Fractures so produced, however, will be most discernible on the *internal* (or posterior) surface, and generally *in or near the mesial line.*

3. *Violent compression* applied to the *sides of the larynx* (as in ordinary *manual throttling or strangulation by grasping*) is, of all applied forces, the most likely to produce fractures of the alæ of the thyroid cartilage, or even of the cricoid cartilage, and fractures so produced are most perceptible, as well as most extensive, on the *external* (or anterior) surface of the larynx. By this *lateral* mode of applying force, the *hyoid bone* is also most readily broken.

4. That the condition of the larynx in regard to the absence or presence of ossific deposit materially influences its liability to fracture from external violence. If altogether cartilaginous, partial slits or splittings may be produced. If partially ossified, fractures may be produced by a comparatively moderate degree of applied violence, and if extensively or entirely ossified, extreme violence will generally be required to produce laryngeal fracture ("Edinburgh Medical Journal," 1855-56).

In France a favourite mode of committing suicide by suffocation is the use of irrespirable gases—carbonic acid, carbonic oxide, and the like. Collateral circumstances must be taken into consideration, and will more or less help to point to the true cause of death.

HANGING, STRANGLING, AND THROTTLING.

Hanging.—Death by hanging is caused by the more or less perfect suspension of a body by a cord applied round the neck, the weight of the body acting as the constricting force.

Strangling.—Death due to pressure made on the neck by any form of ligature carried circularly round the neck. The cord in hanging is as a rule placed more obliquely than in strangulation.

Throttling.—Death due to the constant pressure of the fingers on the throat.

The cause and nature of the death in all of its forms just mentioned are in general the same. Pressure on the trachea—thus arresting respiration—and also on the important vessels and nerves of the neck, results in death, which may be brought about in four different ways:—

1. Cerebral congestion, or apoplexy.
2. Congestion of the lungs and heart—apnœa or asphyxia.
3. Combination of above—apoplexy and asphyxia or apnœa.
4. Neuro-paralysis—nervous apoplexy, or syncope.

The following Table will show the relative frequency of each form of death :—

	Remer.	Casper.
Apoplexy,	9	9
Asphyxia,	6	14
Mixed,	68	62
	83	85

HANGING AND STRANGULATION.

Death may occur in any of the forms above stated. Sensibility is soon lost, and death rapid. The external appearances are more or less those described under "Death from Suffocation." In the greater number of cases, the face bears a quiet, placid expression, no turgidity or lividity being noticeable. The eyes are not protruded. The tongue does not hang out of the mouth, nor is it bitten by the teeth. This accords with the account given of the appearance of the face of the murderer Peace hanged at Leeds.

Turgescence of the male and female genitals is said by some to take place. Casper states that in not one of the many cases he had examined of persons hanged has he ever "found an erection of the male organ," and he also asserts that the emission of semen is extremely rare. Seminal emissions take place more frequently in persons who have been shot, and also in those who have been poisoned by irrespirable gases or by hydrocyanic acid. As a test of strangulation, it is therefore worthless. The escape of urine or fæces may occur. Tardieu, however, only noticed it in two out of forty-one cases; it is by no means a test of hanging, as it may occur after death if the body is shaken in a cart, or roughly used when first found. A fat person dying of apoplexy may have a mark round the neck as if strangled. Injury to the spinal cord due to fracture or dislocation of the cervical vertebræ is rare in suicidal hanging. Fracture of the spinal ligaments and of the hyoid bone is also rare. Rupture of the internal and middle coats of the carotid arteries sometimes occurs. But it appears that considerable damage is done to the soft parts of the neck by the present judicial mode of hanging with the "long drop."

Dr Dyer has recorded ("New York Medical Journal," vol. 3, 1866), some experiments he made on the eyes

of a man and some dogs killed by hanging. He found certain transverse fissures across the lens, which he is inclined to think are characteristic of this mode of death. Dr R. F. Hutchinson states that an invariable sign of death from hanging is *the flow of saliva out of the mouth, down the chin, and straight down the chest.* The appearance is unmistakable and invariable, and *could not occur in a body hung up after death,* the secretion of saliva being a living act (Chevers). Death from hanging may take place although the toes or other parts of the body rest on the ground. Death is complete in four or five minutes.

Marks of the Cord, etc.—The mark of the cord is nearly always present, but is often interrupted, sometimes only seen on one side. In strangling, the mark is low down, most frequently encircling the neck; in hanging, the mark is generally above or on the thyroid cartilage, and carried obliquely upwards. The mark of the cord may be of a dirty yellowish-brown colour, and, when cut into, feels more or less hard and leathery. In general appearance it is not unlike the mark left by mustard plasters or blisters applied within a short time of death. This effect is probably produced by the rubbing off of the epidermis, and subsequent drying up of the cutis on exposure to the air. At other times the mark may be of a dirty-reddish or bright-blue colour; or, lastly, there may be little or no mark present, or the edges may assume a livid red colouration, being nothing more or less than a *post-mortem* stain.

THROTTLING.

The marks left by the act of throttling are similar to those produced by hanging and strangulation, only differing in form. The impression of the fingers is upon opposite sides of the throat; and are more or less separated. The skin presents at times the parchment-like appearance just described, with slight ecchymosis

under the patches. The impressions left by the nails may sometimes be seen.

May the Mark of the Cord be produced after Death?—On this point Casper says: "That any ligature with which any body may be suspended or strangled, not only within a few hours, but even days after death, especially if the body be forcibly pulled downwards, may produce a mark precisely similar to that which is observed in most of those hanged while alive." And the same authority also adds that "the mark of the cord is a purely cadaveric phenomenon."

Suicide or Homicide?—The answer to this question must be framed in accordance with the history of the case, and the attendant circumstances under which the body was found.

Homicidal hanging is so rare as scarcely to require notice, and it also pre-supposes a considerable amount of strength on the part of the assailant to accomplish his purpose.

Suicidal hanging—a favourite mode of death with suicides—is common enough. The absence of marks of injury on the body found suspended, and the want of evidence as to a previous struggle having taken place, all point to suicide. Throttling is never suicidal; strangulation may or may not be the act of a suicide, but the evidence is in favour of homicide.

It must also be remembered that murderers not infrequently suspend their victims after death, to give an air of suicide to the transaction. The presence of considerable injury about the neck militates greatly against the possibility of suicide. In all doubtful cases, therefore, the stomach should be examined for poison, and the body for bruises, which latter may, however, be inflicted by the suicide on himself in his struggles before death ensues. The fact that the feet are found in contact with the ground does not militate against the probability of suicidal hanging; and it appears that in

India the natives seldom hang themselves from any height, and are most frequently found with their feet on the ground.

DROWNING.

Death by drowning occurs when the breathing is arrested by watery or semi-fluid substances, blood, urine, or the muddy semi-fluid matter found in cesspools and marshes. It is not necessary for the whole body to be submerged. Death may result if the face alone be immersed, as in the case of a man in a fit of drunkenness being drowned in the water contained in the imprint of a horse's hoof left in the mud.

In addition to the changes in the internal organs, identical with those present in persons who have died from suffocation or hanging, water is found in the lungs or stomach.

Death may be due to—

(*a*) Apoplexy. (*b*) Asphyxia. (*c*) A combination of the two. (*d*) Neuro-paralysis.

Death from pure apoplexy is rare; and it may be affirmed that death from syncope never occurs in the drowned without leaving some of the signs of asphyxia. Is it not a little absurd to describe death from syncope, even in the case of bodies found in the water, as due to drowning?

It is more difficult to restore the drowned than those dying from mere stoppage of air from entering the lungs. Few if any persons recover who have been submerged four minutes, and even in cases where this time has been exceeded, followed by recovery, this result is probably due to the person fainting before entering the water.

In death from drowning, the lungs are distended and overlap the heart, and have a peculiar spongy feel. They also contain a quantity of frothy fluid, which cannot be produced in the dead body, as it is the result of

the violent efforts made by the individual to breathe in the act of dying. This frothy condition of the fluid in the lungs is an important sign of death by drowning, especially if the fluid corresponds with that in which the individual is said to have perished. It is just *possible*, however, that the person may have been first suffocated, and then thrown into the water; froth in the trachea being found in those suffocated; but in this case the froth is small in quantity, and not watery. The froth in the drowned is like that made with soap in water, and is not viscid, thus differing from bronchitic exudation. Water in the stomach is an important indication of death from drowning, especially if the water contained in the stomach can be shown to possess the same characters as that in which the body was found. In a great number of cases this, however, must be next to impossible; when it can be identified the value of this sign is enhanced by the fact that water does not enter the stomach in those submerged after death, unless putrefaction be far advanced, or the body has lain in very deep water. Casper concluded that a person had been drowned, by finding a small quantity of mud in the stomach after putrefaction had set in. Water, however, may be absent from the stomach if the person fall into the water in a state of syncope, and it may be present if the person have taken a draught of water before submersion.

The effect of season on putrefaction in water is shown in the following Table:—

Summer.			Winter.
5 to 8 hours	produce	as much change as	3 to 5 days.
24 "	"	"	4 to 8 "
4 days	"	"	15 "
10 to 12 "	"	"	28 to 42 "

(Devergie.)

Of the external signs, the presence of sand, gravel, or mud under the nails, may or may not be an important

sign, for sand or mud may collect under the nails during the efforts to drag the body from the water, but weeds, etc., grasped in the hands show that there has been a struggle, and points to death from drowning. The *cutis anserina*—goose skin—present generally on the anterior surface of the body, and not, however, peculiar to death from drowning, is important as a sign of recent vitality. The face of those who have been drowned, and then quickly removed from the water, is pale, and in most cases not swollen; the eyes may or may not be closed; and not infrequently round the mouth there is more or less froth, especially when death is due to apnœa. In summer, however, after two or three days, and longer in winter, the face assumes a reddish or bluish-red colouration, putrefaction taking place about the head and upper extremities earlier than in other forms of death. The *contraction or retraction of the penis* is a well-marked sign of death by drowning, and Casper asserts that he has "not observed anything similar so constantly after any other kind of death." Ogston states that he has met with two cases of erection of the penis in the drowned.

The question as to how long a body may remain in the water before it floats has given rise to considerable discussion, without, however, arriving at any very definite conclusion. It may be stated in general terms that, as floating depends to some extent on the rapidity in which putrefaction supervenes on submersion, bodies float earlier in summer than in winter, in salt than fresh water, clothed than naked. In India bodies have floated in twenty-four hours after immersion. Females and children float more readily than males. A body from various causes may float within a few hours of its submersion, especially if the body be that of a female, fat and clothed. The old idea that the body of a person thrown into water during life sinks but that a dead body under like conditions floats, is a fiction now exploded.

Suicide or Homicide?—Homicide by drowning is rare, except in children. Accidental and suicidal drowning are common enough.

The signs to be sought for in the drowned are—(1) Absence of any injury. (2) *Cutis anserina* and retracted penis. (3) Water and mud in the stomach. (4) Froth in the air-passages. (5) Distended lungs. (6) General signs of death by asphyxia.

It should be remembered that the fact of the hands being tied together, or to the feet, does not militate against suicide by drowning.

If wounds and other injuries be found on the body, the question arises as to whether the injuries were sufficient in themselves to cause death, and then as to whether they were caused during life. A person jumping from a height into the water may sustain severe injuries—dislocation of both arms, fracture of the skull and of the vertebræ. or even lacerated wounds of more or less severity. The absence of the signs proper to death by drowning, coupled with the presence of external injuries, would point to death by violence prior to immersion.

The following considerations may assist in forming an opinion :—

1. Previous history of person found in the water.
   (*a*) Any history of suicidal tendency.
   (*b*) Any motive that would render suicide probable.
2. Height from which the person fell.
3. Absence or presence of signs of death by drowning.
4. Absence of stakes or other objects in the water that might have caused injuries to any one falling against them.

The time required to cause death by drowning is so short, that persons seldom recover after submersion for three or four minutes ; but the cessation of respiration is no guide to the extinction of life, and an attempt at resuscitation should always be made; for if the

respiration be fairly restored the heart will soon act. Nay more, as pointed out before, in cases of so-called asphyxia, the heart may continue to act for several minutes after the entrance of air to the lungs has been arrested, and in judicial hanging it frequently happens that the pulse at the wrist can he felt for ten or twelve minutes after suspension.

Recapitulation of the Post-mortem Appearances in the Drowned.

I.—EXTERNAL.

1. *In the Skin.*—The presence of *goose skin—cutis anserina,* is hardly ever absent, even in summer. The *cutis anserina* is not however, characteristic of drowning, as it may be present in other forms of violent death, and also in some persons during life. It is a vital act, the result of nervous shock, and does not depend upon the temperature of the water for its production ; still it points to recent vitality.

2. *The Tongue.*—The tongue is just as often found behind the jaws as between them " (Casper).

3. *The Hands and Feet.*—The hands and feet acquire a greyish-blue colour when the body has lain in the water from twelve to twenty-four hours. The skin also becomes corrugated in longitudinal folds. The greyish-blue condition of the hand is known as the "cholera hand." The nails may contain particles of sand and weeds. "No corrugation or discolouration of the skin of the hands or feet is ever observed on the body of any one drowned, who has been taken out of the water within half-an-hour, within two, six, or even eight hours" (Casper). The same authority states he has produced these effects by laying the hands after death in water, or wrapping them in cloths kept constantly wet for a few days.

4. *The Genitals.*—Contraction of the penis is an almost constant symptom, and Casper has "not observed anything similar so constantly after any other kind of death." It is due, probably, to the same cause as the *cutis anserina,* which Brettner attributes to "bundles of unstriped muscular fibres, lying in the upper stratum of the true skin, surrounding the sebaceous glands, and forcing them forwards by their contraction, thus making the *cutis anserina.* Precisely similar unstriped muscles are found in the subcutaneous cellular tissue of the penis ; they run principally parallel to the

long axis of the member, but very often large bundles run across it." The action of cold and fright is to induce contraction of these cutaneous muscles, with a resulting contraction of the penis.

II.—INTERNAL.

1. *The Brain.*—Cerebral hyperæmia is *most* rare in the drowned, but cerebral hypostasis is not infrequently mistaken for it.

2. *The Trachea.*—The mucous membrane of the trachea and larynx is always more or less injected, and is of a cinnabar-red, which must not be mistaken for the dirty brownish-red colour, the result of putrefaction. A white froth, but seldom bloody, is also found in varying quantity in the trachea, and is a most important sign of vital reaction, but its diagnostic value is destroyed by putrefaction. Sometimes a portion of the contents of the stomach may be found in the trachea. When this occurs it is due to the act of coughing, induced by the admission of water into the lungs. The contents of the stomach are forced into the mouth, and then drawn into the lungs during the next attempt at inspiration. This indicates that the person entered the water during life. In cases where death has taken place from syncope little or no froth may be found in the trachea.

3. *The Lungs.*—The lungs are completely distended, almost entirely overlapping the heart, and pressing close to the ribs. They are spongy to the feel, and when cut into, a considerable quantity of bloody froth escapes. The *froth* found in the lungs is the result of the powerful attempts to breathe, and cannot be produced by artificial means. It adheres not to the sides of the bronchial tubes, as does the exudation of bronchitis or pneumonia. The distention of the lungs is due partly to an actual hyperæria, partly to inhaled fluid, and partly to hyperæmia.

4. *The Heart and Great Vessels.*—As is common to other forms of asphyxia, the left side of the heart is entirely, or almost entirely empty ; the right, on the contrary, is engorged. This condition of the heart is, therefore, not a diagnostic sign of drowning, and is absent in the drowned when death takes place by neuro-paralysis ; in fact, in some cases of undoubted drowning, both sides have been found empty, probably, however, the result of putrefaction (OGSTON). The same may be said of the accompanying congestion of the pulmonary artery.

5. *The Blood.*—As is common in all forms of death where respiration has been arrested, the blood is found to be remarkably *fluid*, and of a cherry-juice colour. M. Faure in his monograph on asphyxia states that he has found large and firm clots in the right side of the heart in the drowned who have not remained long under water.

6. *The Stomach.*—Casper considers that the presence of fluid in the stomach, corresponding to that in which the body is found, is "an irrefragible proof of the actual occurrence of death from drowning," and that the swallowing of it must have been a vital act of the individual dying in the water.

N.B.—Putrefaction in the drowned in most cases commences in the upper part of the body, and extends downwards. The face, head, and neck are first attacked. This is the reverse of putrefaction in air.

RESTORATION OF THE DROWNED.

Several methods for the restoration of the drowned have been proposed; those by Marshall Hall and Silvester being the best known. More recently, however, Dr Benjamin Howard has proposed a plan, called by him the "direct method." A detailed account of the various methods was given in the "Medical Examiner" for August 1877. The mode of procedure, recommended by Dr Howard is as follows:—

The clothes are rapidly removed and rolled up into the form of a bolster; the patient is then turned on his face, with the bolster under the pit of the stomach, the head being the most dependent part. The object is to allow all fluid to escape from the mouth and throat. This is more effectually accomplished by the operator placing both hands upon the back of the patient, immediately above the bolster, and forcibly compressing the stomach and lower part of the chest against the bolster for a few seconds, two or three times, with very short intervals. He now quickly turns the patient on his back, the bolster beneath it, again making the epigastrium and anterior margins of the costal cartilages the highest point of the body, the shoulders and occiput barely resting on the ground. The operator now seizes the patient's wrists, and having secured the utmost possible extension with them crossed behind the patient's head, pins them to the ground with his left hand, so as

to maintain the required extension. With the right thumb and forefinger, armed with the corner of a dry pocket-handkerchief, he withdraws the tip of the tongue, holding it out at the extreme right corner of the mouth. In this position, two-thirds of the entrance to the mouth is quite free, and the tongue is immovably fixed forward. The epiglottis, by this backward curvature of the neck, is precluded from pressure and partial closure from the undue flexion of the neck so frequently observed. The free margins of the costal cartilages are as prominent as they can be made, and there is a degree of fixed thoracic expansion not obtainable in any other manner. The epigastrium being the highest point, the abdominal viscera, instead of embarrassing the movements of the diaphragm, tend to gravitate away from it. Having given the wrists and tongue into the care of an assistant, the operator now stands astride the patient's hips, resting the ball of each thumb upon the corresponding costo-xyphoid ligaments, the fingers falling naturally into the lower intercostal spaces. Now, resting his elbows against his sides, and using his knees as a pivot, he throws the whole weight of his body slowly and steadily forward until his mouth nearly touches the mouth of the patient, and while he might slowly count one—two—three ; then *suddenly*, by a final push, he springs back to his original erect posture on his feet, remains there while he might slowly count one—two—three ; then repeats, and so on about eight or ten times a minute. As soon as respiration is sufficiently restored, the patient may be placed in a hot bath, then well dried, and placed in blankets, and given hot coffee or tea to drink.

STARVATION.

Death from starvation comes in as an item in the ill-treatment of children, it has also been known as a form of suicide, chiefly among lunatics. The question

of death from starvation may be raised in a case of infanticide by omission. Little is known for certain as to the length of time required to cause death by starvation, but it is certain that life may be prolonged for some time without food, if water be allowed. In a case recorded in the "Lancet," a man who had been shut up in a coal-mine for twenty-three days with only a little dirty water to drink, lived three days after his liberation, and then died of exhaustion. The symptoms, only important for examination purposes, are—pains in the abdomen, relieved by pressure, intense thirst, redness of the eyes, increasing emaciation, dusky dry skin, exhaustion, and ultimately delirium ending in death.

The morbid appearances are extreme anæmia and emaciation, together with remarkable attenuation of the coats of the intestines. The eyes are red and open. This appearance is not common in death from other causes. The tongue and throat are dry, even to aridity, and the stomach and intestines are contracted and empty; this last mark has been repeatedly noticed (Beck).

Diagnosis.—The absence of any other cause for death—such as cancer of the stomach, stricture of the œsophagus, etc.,—and the previous history of the case, will assist in forming an opinion, care being taken not to confound the results of wasting disease with those due to starvation.

Legal Relations.—Although rare as an act of homicide, it must be remembered that the law does not require the absolute deprivation of food to be proved, but only that the necessary quantity and quality of food has been withheld; but malice at the same time must be proved. In cases of infanticide by starvation, the mother and not the father is responsible for the proper feeding of the child; but in the case of an apprentice, the master and not his wife is bound to supply proper food to such apprentice.

Recapitulation of the Post-mortem Appearances of Death by Starvation.

1. *In the Body generally.*—Marked general emaciation of the body. The skin is dry and shrivelled, sometimes more or less covered with unhealthy-looking pimples, the muscles soft, reduced in size, and free from fat. A peculiar fœtid acrid odour is given off from the body.

2. *In the solid Viscera of the Thorax and Abdomen.*—The liver is small, the gall bladder puffed with bile, and the heart and kidneys deprived of any surrounding fat. All the internal organs are shrivelled and bloodless.

3. *In the Stomach and Intestines.*—The stomach in some cases is quite healthy, but more or less stained with bile; in others it is found collapsed, contracted, empty, and the mucous membrane more or less ulcerated. The intestines are thin, contracted, empty, and so shrunken that the canal is almost obliterated. According to the late Dr Duncan, the intestines are frequently found inflamed and ulcerated.

DEATH FROM COLD.

This form of death is rare in England, but is more common in countries where the winters are severe. Anything that depresses the vital powers renders the individual more or less amenable to cold; such, for instance, as drunkenness, previous illness, or deficiency in the amount of food. The following *post-mortem* appearances are given by Ogston, who holds that they point, in the absence of any other obvious cause of death, "if not with absolute certainty, yet with high probability," to death caused by cold:—

1. An arterial hue of the blood generally, except when viewed in mass within the heart; the presence of this colouration not having been noted in two instances.

2. An unusual accumulation of blood, as in Quelmalz and Cappel's cases, on both sides of the heart, and in the larger blood-vessels of the chest, arterial and venous.

3. Pallor of the general surface of the body, and anæmia of the viscera most largely supplied with blood. The only exceptions to

this were moderate congestion of the brain in three cases, and of the liver in seven of them.

4. Irregular and diffused dusky-red patches—"frost erythems"—on limited portions of the exterior of the bodies, encountered in non-dependent parts, these patches contrasting forcibly with the pallor of the skin and general surface.

These signs are not so well marked in children as in adults. The late Sir Benjamin Brodie considered that the effect of cold is to destroy the principle of vitality equally in every part, and that it does not exclusively disturb the functions of any particular organ. The fact of a body found frozen is no proof that death has been brought about by cold.

Diagnosis.—The general appearance of the deceased, and the absence of any other cause of death, together with the appearances just mentioned, will assist in forming an opinion on this difficult subject. The body lies as if in a deep and calm sleep, without any external appearance to guide us as to the cause of death, except perhaps a swelling of the extremities, which has come on prior to death. If a body be found buried in snow, and putrefaction present, death did not in all probability take place from cold, provided that the cold has been severe and continuous. Death from cold is generally accidental, except in newly-born children, when it may be either accidental or homicidal, according to circumstances.

DEATH BY LIGHTNING.

Death is not always immediate. Sometimes the clothes have been torn off the body with scarcely any personal injury. Steel articles worn about the person may become magnetic. Wounds on the body sometimes appear in the form of punctured wounds, at others as lacerated wounds. Not infrequently those killed by lightning are found in the same position that they

occupied during life. The question may be raised as to whether the deceased died by lightning or by violence. The presence of a storm at the time when the death is stated to have occured, and other attendant circumstances, will in most cases point to the true cause of death.

SUICIDE.

In medico-legal inquiries, it not infrequently becomes a question of the greatest importance to decide whether the death of a person found under peculiar circumstances was brought about by accident, suicide, or by the hand of a third party. Unfortunately, there are no infallible rules to be laid down on this subject; and Casper sagaciously remarks that "the exercise of a sound judgment, which is of far more value in medico-legal matters than all the subtleties of the ancient *medicina forensis*, must be our guide." But in order to attract the attention to some important matters in the inquiry, a few points worthy of notice will be placed in a tabular form :—

1. *Has the deceased made any oral statement, or left any written declaration of his intention to commit suicide?*

2. *Has there been any marked peculiarity in the conduct and manner of the deceased to point to any mental derangement?*

3. *Conditions under which the dead body was found.*

   (*a*) If in a room, was the door locked on the inside?

   (*b*) Position of the hand with regard to the weapon alleged to have been used.

   (*c*) If the weapon be firmly grasped in the hand, probability is in favour of suicide, as weapons placed in the hand after death to simulate suicide can be removed with ease, even when the rigor mortis is present.

4. *Nature and character of the wounds found on the body.*

   On suicides, incised and punctured wounds are generally found—seldom lacerated wounds, unless a jump from a height have been the means adopted to cause death.

5. *Evidence to be derived from a medico-legal examination of the body.*

   (*a*) Do the wounds correspond with the weapon alleged to have been used?

   (*b*) Examination of stomach for poison.

   Why? Persons may have been poisoned first, and then cut about the body after death.

   (*c*) Direction and course of wound.

   (*d*) Were the wounds inflicted during life?

With regard to the legal relations of suicide, an attempt to commit suicide is not (within the meaning of sec. 15, of 24 and 25 Vict., c. 100) an attempt to commit murder, but it still remains a common law misdemeanour, triable at quarter sessions (R. *v.* Burgess). If two persons mutually agree to commit suicide by poison or other means, and one survive, the survivor is guilty of murder (R. *v.* Dyson, R. and R. 253). Also if any one, in attempting to commit suicide, cause the death of another, he himself recovering, he shall be guilty of manslaughter (R. *v.* Gathercole). In most of the English Insurance Offices, suicide is held to invalidate a policy, but in most cases where insanity is proved, the amount of the policy is paid (as in the case of Schwabe *v.* Clift). Suicides are deprived of the rites of Christian burial (4 Geo. IV., c. 52, sec. 1), and their bodies used to be buried where four roads met, with a stake driven through the coffin-lid; but a more recent Act now allows the bodies of suicides to be buried in churchyards, though without any religious ceremony.

OFFENCES AGAINST CHASTITY.

RAPE.

According to the Statute (24 and 25 Vict., c. 100 sec. 48), rape in England is defined as the "carnal knowledge of a woman against her will." In Scotland

rape is held to be "the carnal knowledge of a woman forcibly and against her will, or of a girl below twelve years of age, whether by force or not" (Hume 1, 303). An Act passed in 1885 (48 and 49 Vict., c. 69), has materially affected the law on this subject as regards the age of females. To constitute the offence of rape, there must be *penetration*, but proof of the actual emission of seed is not now necessary. Before the Statute (9 Geo. IV., c. 31, sec. 18), it was also necessary to prove emission, which might be proved either positively by the evidence of the woman that she felt it, or it might be presumed from circumstances; as, for instance, that the defendant, after connection with the prosecutrix, arose from her voluntarily without being interrupted in the act. The slightest penetration of the male organ within the vulva will be sufficient, and the hymen need not be ruptured (R. *v.* Russen, 1 East P.C., 438, 439). The resistance of the woman must be to the utmost of her power. If, however, the woman yield through fear or duresse, it is still rape; but of course much will depend upon the previous character of the woman, and her conduct subsequent to the alleged outrage. The party ravished is a competent witness to prove this and every other part of the case; but the credibility of her testimony must be left to the Jury. The defendant may produce evidence of the woman's notoriously bad character for want of chastity or common decency, or that she had before been connected with the prisoner himself; but he cannot give evidence of any other particular facts to impeach her chastity (R. *v.* Hodgson, R. and R. 211). She may be asked if she has had connection with other men, but she need not answer (R. *v.* Cockcroft, 11 Cox, 410, per Willis, J.). If she deny connection with the men named to her, they cannot be called to contradict her (R. *v.* Holmes, L.R. 1 C.C. R., 334).

A rape, according to Scotch law, may be committed on a common strumpet; and in England the law goes

even further, and admits the possibility of rape on the concubine of the ravisher (1 Hale, 729), "although such circumstances should certainly operate strongly with the Jury as to the probability of the fact that connection was had with a woman against her will." A husband may be guilty of rape on his wife if he hold her while another violates her, as in the case of the Earl of Castlehaven, tried in 1637. Carnal knowledge of a woman by fraud, which induces her to suppose it is her husband, now constitutes a rape by the 48 and 49 Vict., c. 69, which enacts that "whereas doubts have been entertained whether a man who induces a married woman to permit him to have connection with her by personating her husband, is or is not guilty of rape, it is hereby enacted and declared that every such offender shall be deemed to be guilty of rape." It has also been decided that if a man get into bed with a woman while she is asleep, and he know she is asleep, and he have connection with her while in that state, he is guilty of rape (R. *v.* Mayers, 12 Cox, 311, per Lush, J.). The offence of rape is not triable at quarter sessions.

Upon an indictment for rape, there must be some evidence that the act was without the consent of the woman, even when she is an idiot. In such a case, where there was no appearance of force having been used to the woman, and the only evidence of the connection was the prisoner's own admission, coupled with the statement that it was done with her consent, the Court held that there was no evidence for the Jury (R. *v.* Fletcher, L.R. 1 C.C. R., 39).

In another case, where the prisoner was caught in the act by the father of an idiot girl, the learned Judge told the Jury that if the prisoner had connection with the prosecutrix by force, and if she was in such an idiotic state that she did not know what the prisoner was doing, and if the prisoner was aware of her being in that state, they might find him guilty of rape; but

if, from animal instinct, she yielded to the prisoner without resistance, or if the prisoner, from her state and condition, had reason to believe she was consenting, they ought to acquit him. The Jury found that he was guilty of an attempt at rape (R. *v.* Barratt, L.R. 2 C.C., 81).

Where the prosecutrix, an apparent idiot, proved that the prisoner had had connection with her, but it appeared from her examination that though she knew he was doing wrong, she made no resistance, and the prisoner, on being apprehended and charged with committing a rape upon the prosecutrix "against her will," said "Yes, I did, and I'm very sorry for it," it was held that there was evidence to go to the Jury of a rape (R. *v.* Pressy, 10 Cox, 635).

In Scotland, in the case of Hugh M'Namara (H.C., July 24, 1848, Ark., 521), where the woman was only one degree removed from idiocy, it was laid down that "if she had shown any physical resistance, to however small an extent, the offence would be complete, in consequence of her inability to give a mental consent."

In future cases the above decisions will probably be set aside in the light of the present enactment.

In the case also of a quack doctor, who, under the pretext of performing a surgical operation on a young girl of nineteen years of age, had connection with her, she at the time resisting, but believing that she was undergoing an operation, it was held, on appeal, that he was guilty of the crime of rape, and the former conviction confirmed (R. *v.* Hattery, C.C.).

In England, and in Ireland, and also in Scotland unlawfully and carnally knowing a girl under thirteen years of age constitutes a felony—the attempt, in the former countries constitutes a misdemeanour; in Scotland, a "crime and offence." The child may be a witness if she understands the nature of an oath or understands the duty of speaking the truth, but her evidence must be corroborated by some other material evidence in support thereof, implicating the

accused. The carnal knowledge of a girl above thirteen and under sixteen, or of any female idiot or imbecile woman or girl, under circumstances which do not amount to rape, but which prove that the offender knew at the time of the commission of the offence that the woman or girl was an idiot or imbecile, constitutes a misdemeanour. Above sixteen, consent does away with the crime; and it shall be a sufficient defence for the accused to show that he had reasonable cause to believe that the girl was of or above the age of sixteen years. This offence does not apply to female idiots or imbeciles.

A boy under the age of fourteen was formerly in England presumed by law incapable of committing a rape (R. *v.* Groombridge, 7 C. and P., 582); but in Scotland there was no such provision, and a boy thirteen and a-half years of age was committed for rape (Rob. Fulton, jun., Ayr, Sept. 20, 1841).

The recent Act before quoted, provides that, instead of imprisonment, the offender, if *under* sixteen, may be whipped and sent to a reformatory school for not less than two or more than five years. Evidently age cannot now be pleaded as an incapability.

The crime of rape appears to be most frequently perpetrated against children, probably due to the popular idea that an attack of gonorrhœa may be cured by connection being had with a virgin or healthy female.

The following Table from Casper gives the result of his examination of one hundred and thirty-six cases of rape:—

From $2\frac{1}{2}$ (!)	to 12	years old,	99
" 12	" 14	"	20
" 15	" 18	"	8
" 19	" 25	"	7
	47	"	1
	68	"	1
			136

In examination of a case of alleged rape, several points of interest will have to be considered, which, for the sake of convenience, will be placed in a tabular form :—

1. *An examination of the parts of generation.*
   (*a*) Inflammatory redness and abrasion of the parts.
   (*b*) A muco-purulent secretion.
   (*c*) Hæmorrhage or dried blood about the genital organs.
   (*d*) Destruction of the hymen.
   (*e*) Dilatation of the vagina.
   (*f*) General signs of rape.
2. *An examination of the body and limbs of the female.*
3. *Examination of the linen worn by the female and the male for*
   (*a*) Marks of semen.
   (*b*) Marks of blood.
   (*c*) Marks of other discharges, gonorrhœa, etc.

1. An Examination of the Parts of Generation.—

1. More or less inflammatory *redness* and *abrasion* of the mucous membrane lining the parts, which is never absent in children, and may last for some weeks. "In adults, virgins up to the time of the commission of the crime, this appearance is either not found at all, or only faint traces of it. In those previously deflowered it is never observed." In the case of young children the genitals may be so injured as to cause death in a few hours. The parts may therefore present all varieties of injury, from slight bruising and redness to the most fearful lacerations.

> *Caution.*—Inflammatory irritation due to catarrh *may* occur, and be apt to mislead.

2. A *muco-purulent secretion*, from the mucous membrane lining the vagina, of a greenish-yellow colour, more or less viscid, and soiling the linen of the girl. This secretion, in colour and consistence, cannot be distinguished from that the result of gonorrhœa. The usual period of incubation of gonorrhœa is from three to eight days; among young girls, however, this period

may be shortened. The incubatory stage of simple chancre is from three to five days (DIDAY); that of hard chancre somewhat longer, varying from fifteen to twenty days. Enlargement of the inguinal glands and the persistence of the discharge after the use of simple treatment will tend greatly to confirm the suspicion of venereal disease. The genital organs of the male may have to be examined as to the presence of gonorrhœa or syphilis. Syringing the urethra may remove for a time the gonorrhœal discharge; care must therefore be taken in forming an opinion.

Caution.—Unhealthy children, and those recovering from some debilitating diseases—fever, etc.,—may suffer from purulent discharges from the vagina. Small ulcers may also be present, and may be mistaken for syphilitic ulceration. Infantile leucorrhœa is not uncommon. (PERCIVAL'S "Medical Ethics.")

3. *Hæmorrhage or Dried blood about the genital Organs.*—(1) Frequently absent in young children. (2) Always found in adults, virgins at the time the rape was committed, when the vessels of the hymen are ruptured.

4. *Destruction of the Hymen.*—Most frequently, and especially in young girls, one or more *lacerations* of the hymen may be seen. These lacerations must be looked for within five or six days of the alleged rape, as they soon heal up, and then no certain opinion can be given as to the date of their infliction. They may also be produced by any foreign body to substantiate a charge of rape.

5. *Dilatation of the Vagina.*—This condition may be produced by the passage of hard bodies in order to substantiate a false charge of rape. Casper once examined a girl, only ten years of age, whose mother had gradually dilated her vagina with her fingers, in order to fit her for sexual intercourse with men.

6. *General Signs of Rape.*—To the above are added certain general signs, as a *difficulty in walking*, attended

with an involuntary separation of the thighs, common to both children and adults; *pain is also not infrequently present in passing water*, and when the *bowels are relieved.* In determining the truthfulness of the statements made as to an alleged rape, the character of the woman, and the obvious inconsistencies of her statements, must be taken into consideration. Moreover, if in addition to the injuries found on the external genitals, spermatozoa be detected in the vagina, a presumption in favour of the injuries being due to sexual intercourse will be clearly made out, but the presence of spermatozoa in the vagina of a woman is no evidence of rape. Care, however, must be taken not to confound with spermatozoa an animalcule—trichomonas vagina—described by M. Donné as being sometimes found in the vaginal mucus. The head of the animalcule is larger than that of a spermatozoon, and is surrounded by a row of cilia.

In the case of young children, the anxiety on the part of the parents of the child to push the charge, and the story of the child and that of the parent heard apart, may assist in guiding the opinion. The lesson-like way in which the child tells her story, even to the minutest details, is always suspicious. The proof of a previous defloration negatives the pretended loss of virginity at the time of the commission of the deed for which the accused is being tried. In most cases, it is best to let the patient tell her own tale, and then cross-examine. An injudicious question may put her on her guard.

2. Examination of the Limbs and Body of the Female for Bruises, etc.—Little value is to be placed on injuries said to be inflicted on the person of the female, the result of a struggle, as these may be produced by the woman on herself in order to substantiate her story. In children, for obvious reasons, they do not occur.

3. Examination of the Linen.—In all cases a careful examination of the body linen of both parties should be made. With regard to the position of the stains on the chemise of the woman, M. Devergie insists that the stains on the front of the chemise are seminal, those on the back are due to blood. This distinction is too arbitrary to meet all the facts of these cases, for the position of the spots necessarily depends on the respective positions of the parties at the moment of ejaculation; and moreover, the woman is more likely to wipe the parts with the front than the back of her chemise. Mistakes may arise from—

1. The garments being intentionally soiled with blood. This is not infrequently done in cases of false accusations.

2. The menstrual discharge may be readily mistaken for that due to violence, as the two kinds of blood cannot be distinguished.

3. The red juice of fruits and grease spots have been mistaken for marks of blood and seminal stains on linen.

The identification of blood-stains is not difficult when the stain occurs on pieces of white linen; but when, as it not infrequently happens, they have to be detected on the coarse, dirty, often stinking linen of the poor, the task becomes somewhat more difficult. The same may be said with regard to seminal spots. As a means of diagnosis in stains due to semen, the appearance and smell of the stains are of no assistance whatever. The microscope will alone give any trustworthy evidence as to the nature of the stain; and even here a caution must be added—for the fact is beyond doubt that the semen even of a healthy young man varies much, and is scarcely ever twice alike, so that the absence of spermatozoa is no proof that the spot is not seminal in its origin.

The following are the tests used for the detection of semen:—

1. *Characteristic Smell when the Spot is Moistened.*—This test is of no use, for the reasons before stated.

2. *Appearance when held to the Light.*—As uncertain as the preceding.

3. *Doubtful Spots* upon *Cotton* or *Linen*—not upon *wool*, which usually contains sulphur—should be cut out and moistened with a few drops of oxide of lead, dissolved in liquor potassæ, and then dried at a temperature of 68° F. The stain in a few minutes becomes of a dirty yellow or sulphur-yellow colour. This change in colour proves that the mark *is not* a seminal stain. Semen does not contain albumen. This test only shows that the stain is not caused by albuminous compounds, which contain sulphur; but it does not follow therefore that the spot must be seminal; for marks made by gum, dextrine, and some other substances of a like nature, are not changed in colour.

4. *The Microscope.*—This is by far the most reliable test, but care is required in its manipulation.

(*a*) The cloth must not be rubbed between the fingers, as the spermatozoa may be damaged by the operation.

(*b*) The suspicious spot on the linen should be carefully cut out and placed in a clean watch-glass or small porcelain vessel, and then moistened with a small quantity of distilled water. The cloth may be gently moved about in the water with a glass rod, and gentle pressure made so as to thoroughly wet the cloth, which, in most cases, will be accomplished in about a quarter of an hour. A single drop should now, by gentle pressure with the fingers, be squeezed on to a clean slide, and then placed under the microscope.

(*c*) Another method may be adopted. First determine the side of the cloth on which the stain is present, and cut out the stain, leaving a small strip of cloth attached to the main portion. Place the end of the strip in a little water in a watch glass, so that the water by capillary attraction may permeate the entire stain. With a thin bladed knife gently remove the moistened stain and place it on a microscopic slide, and examine as before.

Can a Rape be committed by one man on a healthy vigorous woman?—The answer to the question will, to a great extent, depend on the relative strength of the conflicting parties. Every case of rape has to be judged on its own merits. In any case, the medical jurist has simply to state, from the examination of the parties, that sexual intercourse has taken place, leaving the Jury to decide whether a rape or not has been perpetrated. A case is mentioned by Casper where a healthy, strong adult of twenty-five years old was violated by a single man.

Can a woman be violated during Sleep?—By this is intended natural healthy sleep, and not that induced by narcotics. In natural sleep, rape is scarcely possible

in a virgin, especially if the hymen be found recently ruptured, though it *may* be possible in a woman accustomed to sexual intercourse.

Can a woman become pregnant by an Act of Rape?—The answer to this question is most decidedly in the affirmative. It is not necessary for a woman to experience any sexual pleasure during connection in order that she may conceive. A woman may become pregnant if fresh semen be injected into the vagina with a glass syringe.

Signs of Rape in the Dead.—In the case of a woman found dead, the question may arise as to her having been violated prior to death. The reply to the question is by no means easy. Severe injury to the genitals is a presumption in favour of rape, but cases are by no means rare in which men failing to accomplish coïtus have injured the parts with their fingers. The presence of spermatozoa in the vaginal mucus is good evidence of a late coïtus, but is no direct evidence of rape. Collateral evidence will in most cases decide the point.

Directions as to manner of making a Medico-Legal Examination in a Case of alleged Rape.

1. Be careful to note everything, for it is in such cases as the one under discussion where apparently unimportant signs may become of the greatest moment.

2. Give the female no time for preparation, but make your visit, and at once proceed to an examination. The visit to be of any practical service should not be delayed beyond the third or fourth day after the alleged offence "by which time the lacerations will have healed, the cicatrices disappeared, and the torn hymen be in such a state as to make it difficult to say whether it had been divided recently or at an earlier period." But remember that you *are not justified in using force;* and in this, as in cases of suspected pregnancy, if you examine a woman against her will you render yourself liable for an action for assault, and may have to pay heavily for your enthusiasm.

(*a*) Note time of visit.
(*b*) Note time of alleged offence. *Why?* May prove the accused party innocent by an *alibi.*
(*c*) Avoid leading questions.

3. Age, strength, and condition of the health of the complainant. Examine the wounds asserted to have been inflicted, and see if they correspond with the history given of their infliction.

4. Examine organs of generation.
   (*a*) Any recent signs of violence—blood, abrasions, ulcerations, etc.
   (*b*) Condition of hymen, and of the *carunculæ myrtiformes.*
   (*c*) Was the woman menstruating at the time? Signs modified or obliterated by menstruation.

5. Preserve any spots on linen, etc., for future examination.

6. In case of death after violence.
   (*a*) Examine mouth for foreign bodies, etc.
   (*b*) Fractures or bruises on the body.

7. Examine spot where the crime is stated to have taken place.

8. Examine person of the accused.
   (*a*) Muscular development and strength.
   (*b*) Any abrasion about the penis, size of penis, rupture of the frænum, etc.
   (*c*) On linen, blood-stains, seminal spots, etc.
   (*d*) Marks on his body, scratches, etc., as evidence of resistance.

N.B.—The lapse of a few days may be sufficient to remove all traces of the violence done to the parts; and in most cases days, weeks, and even months may elapse before an examination is made of the alleged victim.

Physical Signs of Rape in Adult and in Child.

IN THE ADULT.	IN THE CHILD.
1. If examined soon after the commission of the offence, the hymen of the adult virgin may be ruptured, and the fourchette may be lacerated, and the parts covered with blood.	1. There may not be sufficient penetration to rupture the hymen, consequently there will be no hæmorrhage. In other cases the external organs will be bruised, and in many cases severely lacerated, the lacerations depending on the amount of penetration and force used.
2. Difficulty in walking, in passing water, and sometimes when the bowels are relieved. These signs in the adult pass off in a day or two.	2. Same as in the adult, but lasting for a longer time—from eight to fourteen days.
3. Injuries on the person abused, such as scratches and ecchymoses, may be present as the result of a struggle. These may be self-inflicted.	3. For obvious reasons these do not occur on children.

VIRGINITY.

There is no one sign which may be considered as an absolute test for virginity. The presence or absence of the hymen is of no probative value one way or the other. Its very existence has been denied by Paré, Buffon, and others. It may be absent as the result of disease, or as the result of a surgical operation to allow of the free discharge of the menstrual flow. Its presence is no bar to conception; and cases are on record where it has been found necessary to incise it, to allow of the passage of the fœtus into the world. In fact, women who have been prostitutes for years have possessed to the last uninjured hymens. The changes in the breasts which proceed from impregnation do not occur where only defloration has taken place. The rugose condition of the vagina is only affected by the first birth, and not by sexual intercourse.

What has been said of the above signs as tests for virginity may be said of a host of others which from time to time have, with varying success, been advanced as aids to the diagnosis. Casper, however, considers "that where a forensic physician FINDS A HYMEN STILL PRESERVED, EVEN ITS EDGES NOT BEING TORN, AND ALONG WITH IT—in young persons—A VIRGIN CONDITION OF THE BREASTS AND EXTERNAL GENITALS, HE IS THEN JUSTIFIED IN GIVING A POSITIVE OPINION AS TO THE EXISTENCE OF VIRGINITY, and *vice versa.*

PREGNANCY.

It not infrequently happens that a medical man is called upon to make an examination of a woman for legal purposes, in order to decide—(*a*) The existence of an alleged pregnancy. (*b*) The possibility of a previous pregnancy. (*c*) As to the existence of concealed pregnancy.

The following are some of the reasons why pregnancy may be feigned :—

1. *By a married woman, to gratify the desire of her husband for issue.*

2. *To influence the Jury in a case of breach of promise of marriage as to the assessment of the damages.*

3. *To extort money from a seducer or paramour.*

4. *To produce a spurious heir to property.*

The late insane attempt of Lady Gouch to produce an heir is a case in point.

5. *By a single or married woman, to stay the infliction of capital punishment.*

Pregnancy may be concealed—(*a*) In order to procure abortion. (*b*) In order to commit infanticide. (*c*) In the married and the unmarried, to avoid disgrace.

Besides the above, other important questions may arise with regard to this state :—

1. *Is pregnancy possible as the result of coïtus in a state of unconsciousness?* — There appears no reason for doubting the possibility of this occurrence.

2. *Can pregnancy occur before the appearance of the catamenia?* —That pregnancy may occur before menstruation is undoubted ; and it appears probable that the changes in the ovaries and uterus may go on at the regular monthly periods, and yet there may be no discharge of blood from the uterus, which, as pointed out by Bischoff, is only a symptomatic though usual occurrence. Hence, pregnancy is possible prior to menstruation.

3. *What is the earliest and latest age at which pregnancy is possible?*—In our climate (Britain), the earliest age at which pregnancy may occur is about the eleventh or twelfth year ; but the youngest age at which this condition is reported to have occurred is *nine* years (Meyer). In hot climates—as in Bengal—mothers under twelve years of age are by no means rare. Cohabitation in marriage takes place much earlier in India than in Europe, but Chevers doubts if menstruation naturally occurs much sooner there than elsewhere, and Baboo Modusoodun Gupta believes that the catamenia appears sooner or later, according to the mode of living of the females, and the sexual excitement to which they may be subjected. Thomas mentions the case of a girl who menstruated regularly from the age of twenty-one months, and

also of another at eight months. The limit to child-bearing appears to be between the fiftieth and fifty-second years; but even here considerable variation has been recorded, and women have been delivered of children at the age of sixty. Haller even reports one at seventy. As long as menstruation continues a woman may become pregnant; but even the cessation of this flow for some months is no bar to conception.

4. *Is it possible for a woman to become pregnant eight weeks after her last confinement?*—This is undoubtedly possible but it is of rare occurrence. It is also probable that a woman may abort at the end of the time above mentioned. I knew a woman, since dead, who for several years bore a child every ten months.

At *common law*, in cases of disputed inheritance, the following may occur, and give rise to the necessity for medical evidence on the subject:—A woman who has just lost her husband may disappoint the expectant heirs to an estate by alleging that she is pregnant.

At *criminal law*, pregnancy may be used as a stay to the infliction of capital punishment.

In the first case, a jury of matrons is impannelled by a writ *de ventre inspiciendo*, to decide the existence of pregnancy, and if the fact be proved, to watch till such time as she be delivered.

In the second case, in England, the pregnancy must be proved, and also whether she be *quick with child.* In Scotland the pregnancy must be proved, but without reference to *quickening*, and the jury of matrons is unknown in that country. In the same country, if it can be shown that a woman is pregnant, and that her life or that of the child is endangered by her imprisonment, she may be admitted to bail till after delivery. A pregnant female also cannot be compelled to appear and give evidence, if on competent authority it be shown that her delivery will probably take place at the time fixed for the trial.

Signs of Pregnancy.—The diagnosis of early pregnancy in ordinary cases is by no means easy, especially

between the third and fourth months of gestation; but to the medical jurist it is still more difficult, as he has to deal with cases where he can scarcely expect much candour. No opinion should, however, be given without taking into consideration the collective value of the signs as no one sign will afford sufficient data on which to base an opinion. The signs furnished by auscultation are the most reliable, but the position of the fœtus may render the sounds of the fœtal heart and placental souffle difficult to detect.

The following may be taken as among the most important signs of pregnancy, given in the usual order of their occurrence:—

UNCERTAIN OR ACCESSORY SIGNS.

1. Cessation of menstruation,	First month.
2. Morning sickness,	Second month.
3. Salivation,	Variable.
4. Mammary sympathies,	Third month.
5. Enlargement of the abdomen,	Fourth month.
6. Quickening,	Fourth month.
7. Kiesteine,	Variable.
8. Jacquemier's Test,	Third month.

CERTAIN OR ESSENTIAL SIGNS.

1. Ballottement,	Fourth month.
2. Uterine souffle,	Second month.
3. Pulsation of the fœtal heart,	Fourth month.

Uncertain Signs.

1. *Cessation of Menstruation.*—The non-appearance of the catamenia, though a most valuable sign, is by no means a conclusive one, as menstruation may be arrested by diseases of various kinds; while, on the other hand, there are many well-recorded cases of women who have menstruated regularly during the whole period of their pregnancy. There have been also cases in which the menses only occurred during pregnancy; and in a few

still more curious cases, women who have never menstruated have been known to have borne several children. In cases of concealed pregnancy, the woman may smear her linen with blood to imitate the menstrual flow.

2. *Morning Sickness.* — Nausea, often ending in vomiting, generally occurs soon after rising in the morning, and may commence almost immediately, but more frequently not till the expiration of the fifth or sixth week after conception. It is not a reliable sign, and is often very irregular in its occurrence. When present, it varies in degree, from a feeling of nausea to the most violent vomiting, very distressing to the patient.

3. *Salivation.*—The excessive secretion of the salivary glands, due to the irritation caused by pregnancy, was first mentioned by Hippocrates as a sign of this condition. "It is to be distinguished from ptyalism induced by mercury, by the absence of sponginess and soreness of the gums, and of the peculiar fœtor, and by the presence of pregnancy." It is oftener absent than present.

4. *Mammary Sympathies.* — As the breasts may enlarge from various causes—such, for instance, as the distension of the uterus from hydatids, or, as is the case with some women at each menstrual period, when the catamenia are suspended, or after they have ceased—this is by no means a sign on which much reliance should be placed. The change in the colour of the nipple and areola, more apparent in women of dark complexions, is more to be relied on as a diagnostic sign of pregnancy. The first observable alteration, which occurs about two months after conception, is "a soft and moist state of the integument, which appears raised, and in a state of turgescence, giving one the idea that, if touched by the point of the finger, it would be found emphysematous. This state appears, however, to be caused by infiltration of the subjacent cellular tissue, which, together with

its altered colour, gives us the idea of a part in which there is going forward a greater degree of vital action than is in operation around it; and we not infrequently find that the little glandular follicles, or tubercles as they are called by Morgagni, are bedewed with a secretion sufficient to damp and colour the woman's dress." During the progress of the next two months, the changes in the areola are in general perfected, or nearly so, and then it presents the following characteristics:—"A circle round the nipple, whose colour varies in intensityaccording to the particular complexion of the individual, being usually much darker in persons with black hair, dark eyes, and sallow skin, than in those of fair hair, light-coloured eyes, and delicate complexion. The extent of the circle varies in diameter from an inch to an inch and a half, and increases in most persons as pregnancy advances, as does also the depth of colour. In the centre of the coloured circle, the nipple is observed partaking of the altered colour of the part, and appearing turgid and prominent, while the surface of the areola, especially that part which lies more immediately around the base of the nipple, is studded over, and rendered unequal by the prominence of the glandular follicles, which, varying in number from twelve to twenty, project from the sixteenth to the eighth of an inch; and, lastly, the integument covering the part appears turgescent, softer, and more moist than that which surrounds it; while on both there are to be observed at this period, especially in women with dark hair and eyes, numerous round spots or small mottled patches of a whitish colour, scattered over the outer part of the areola, and for about an inch or more all around, presenting an appearance as if the colour had been discharged by a shower of drops falling on the part." The value of the above changes in the nipple and areola as a diagnostic sign of pregnancy is greatly lessened by a previous pregnancy. It should also be remembered that milk may occur in the breasts of women who are not pregnant.

5. *Enlargement of the Abdomen.*—For the first four months of pregnancy the entire uterus is contained in the cavity of the pelvis; it then gradually rises, so that at about the fifth month it is midway between the pubes and umbilicus, which latter it reaches at the end of the sixth month; during the seventh month it may be felt half-way between the umbilicus and ensiform cartilage; at the end of the eighth month it is level with the cartilage, now quite filling the abdomen. Still increasing in size during the ninth month, it does not ascend higher, the abdominal walls yielding to its increased weight, allowing it to fall somewhat forward. A caution is necessary with regard to this sign. The abdomen may enlarge from causes other than pregnancy. Pregnancy and ascites, or ovarian dropsy, may co-exist in the same patient, and the diagnosis rendered anything but easy. The enlargement of the abdomen may lead to unfounded suspicions detrimental to the happiness and health of the unfortunate object of them. The *cervix uteri* in the latter months of pregnancy presents the following characteristics;—At the sixth month it loses one-fourth of its length; at the seventh it is only half of its original length; at the eighth it loses another quarter; and at the ninth the neck is entirely obliterated. This shortening is more apparent than real, and its occurrence is denied by the late Dr J. M. Duncan, except during the last few days of pregnancy.

6. *Quickening.* — The period at which quickening occurs varies from the fourth to the fifth month; and the term is understood to imply the first perception of the movements of the fœtus experienced by the mother. Nervous women, anxious to have children, sometimes complain of sensations which they ascribe to quickening, pregnancy being absent. Pregnancy may occur without quickening.

7. *Kiesteine.*—This is no test of pregnancy, as it may be found in women not pregnant.

8. *Jacquemier's Test.*—A violet or port-wine colour of the vagina and inner surface of the vulva, due to venous congestion of the parts from pressure of the gravid uterus.

A flattening of the upper wall of the vagina, produced by the enlargement and anteversion of the uterus, which, forcing the os towards the sacrum, makes the anterior wall of the vagina tense, has been added by Dr Barnes as a sign of pregnancy.

This ends the account of those signs of pregnancy which are least to be relied on in forming a diagnosis, and which are only useful when taken in the aggregate.

Certain Signs.

1. *Ballottement.*—This test of pregnancy is applied by causing the patient to stand upright; the finger of the right hand is then passed into the vagina and placed on the mouth of the womb, the other hand being placed lightly over the abdomen in order to steady the uterine tumour. If the finger be now jerked upwards against the head of the child, it will be felt to float upwards in the liquor amnii, and then by its own weight gradually to return to its former position. Tumours in the uterus, attached to its walls by a pedicle may give the same sensation. Scanty supply of liquor amnii, or mal-position of the child, may sometimes prevent the adoption of the test.

2. *Uterine Souffle.*—Under this head are included the placental bruit, and the pulsations of the umbilical cord. Both these sounds require a most skilled auscultator to detect them. The uterine murmur, or *bruit placentaire*, is heard best at the lower and lateral portions of the uterus, just above Poupart's ligament. It is isochronous with the pulse of the mother, and is heard most distinctly about the fourth or fifth month of utero-gestation; in some cases, however, it may be heard as

early as the tenth week. The sound is intermittent, and varies in character, being sometimes hissing, whirring, or cooing, at others rasping.

3. *Pulsation of the Fœtal Heart.*—The sounds of the fœtal heart were first noticed by Mayar in 1818, and those of the placenta, or *placental souffle*, by Kergaradec in 1822. The sound of the fœtal heart is composed of a rapid succession of short, regular double pulsations, differing from that of the adult heart in rhythm and frequency. It can be heard more or less over the whole of the abdomen about the middle of the fourth month, and is not unlike the muffled ticking of a watch. In frequency it varies from 100 to 140. The auscultator should be careful not to hang his head down, or he may be apt to mistake the throbbing of his own arteries for sounds communicated from the patient.

The medical jurist must be prepared for the following among many other questions which will come under his notice :—"An unmarried woman with abdominal enlargement has been wrongfully accused of being pregnant. Enumerate the various conditions which produce abdominal enlargement, and give the diagnosis of them." *

Pregnancy may be simulated by ascites, by fibrous tumours of the uterus, by ovarian dropsy, and by enlargement of the uterus from retention of the catamenia due to an imperforate hymen, etc. The breasts may also become affected by uterine tumours.

Diagnosis of Pregnancy.

1. *Pseudo-Pregnancy.*—In the examination of cases of alleged pregnancy, the medical jurist should bear in mind the possibility of enlargement of the uterus and abdomen from the presence of tumours. The probable occurrence of *pseudo-pregnancy* should also be considered.

* See the author's "Collection of Medical and Surgical Questions." Second Edition. London.

Tumours and pseudo-pregnancy may occur in the married and unmarried; and as the latter is not unfrequently accompanied with many of the signs and symptoms of pregnancy, an early diagnosis is of the utmost importance.

The diagnosis will consist in—

(*a*) A careful examination of all the symptoms present, when, in most cases, a break in their order of sequence may be observed, or certain signs may be added which do not occur in true pregnancy.

(*b*) Presence or absence of the hymen.

(*c*) If the patient be placed well under the influence of chloroform, the tumour, if the result of pseudo-pregnancy, will subside gradually returning as the effects of the anæsthetic pass off. Whilst the patient is under the influence of the anæsthetic, the hand may be pressed on the abdomen at each expiration, and there retained, the pressure being continued during the inspirations.

It is stated that Liston once cut into a woman for a phantom tumour, and declared that he had never seen more healthy bowels in his life.

2. *Dropsy.*—Use of the stethoscope; examination of the breasts for milk, and the urine for albumen.

3. *Fibrous Tumours.*—Absence of fœtal movements and other signs of pregnancy.

4. *Ovarian Dropsy.*—Tumour on one side of the abdomen; breasts unaffected, and auscultation giving negative results.

5. *Retention of the Catamenia.*—On examination, the hymen found perfect and bulging. This condition cured by a crucial incision.

DELIVERY.

This subject is best discussed under three heads:—(1) Signs of Recent Delivery in the Living. (2) Signs of Recent Delivery in the Dead. (3) Signs of Previous Delivery.

1. Signs of Recent Delivery in the Living.

(*a*) Transitory Signs; (*b*) Persistent Signs of Delivery.

(*a*) Transitory Signs of Delivery.

1. *General Indisposition.*—The face is pale or flushed; the eyes sunken, and surrounded by a dark areola; there is considerable debility, and a tendency to faint; the skin is warm and moist, and the pulse quick. It must be borne in mind, that a woman who is anxious to conceal her recent delivery may, by an effort of the will, to a great extent hide her real condition.

2. *The Breasts.*—The breasts feel firm and "knotty," and on pressure yield a small quantity of *colostrum* or milk, which may be distinguished by the aid of the microscope.

3. *The Abdomen.*—The skin of the belly shows signs of recent distention; it is relaxed, and more or less thrown into folds, the lower part marked by irregular broken streaks of a pinkish tint, becoming white and silvery as time goes on.

4. *The Lochia, or the "Cleansings."*—These consist in a discharge from the uterus, which, for the first three or four days after delivery, is more or less bloody. During the succeeding four or five days it acquires a dirty-greenish colour—"green waters," with a peculiar sour, rancid odour. In a few days this is succeeded by a yellowish, milky, mucous discharge, which may continue for four or five weeks.

5. *External Parts of Generation.*—The labia and vagina bear distinct marks of injury and distension.

6. *The Uterus.*—The uterus is enlarged, and may be felt by the hand for two or three days after delivery, as a round ball, just above the pubis. The orifice of

the uterus, if examined a few hours after delivery, appears as a continuation of the vagina. This condition completely disappears in about a week after delivery.

7. *After-pains.*—These are of no use from a diagnostic point of view, as we have no means of testing their presence or absence.

(*b*) Persistent Signs of Delivery.

1. *Entire obliteration of the hymen.*—This is no proof of actual delivery.

2. *Destruction of the fourchette.*

3. *The vagina dilated, and free from rugæ.*

4. *Dark colour of the areola round the nipples.*—This varies among women; and I know of one case where there was no areola either during pregnancy or after delivery.

5. *Skin of Abdomen.*—Due to the great distension of the abdomen, the skin appears streaked with silvery lines varying in breadth. These markings in some cases may be scarcely perceptible, especially if the female has worn a tight abdominal belt during her pregnancy. The same appearance may be produced by dropsy, or the prolonged distension of the abdominal walls, the result of other causes. I once saw these markings most characteristically present in a young man just recovered from an attack of ascites. His sex precluded any error in diagnosis as to the cause of the marks. Attention to the other signs present will assist the diagnosis. After the lapse of seven to ten days the recent delivery of a woman cannot be certainly proved by an examination of the living woman, especially if it be known that she had previously borne children. In primipara, the pink-coloured streaks on the abdomen, and the transverse condition of the os uteri, may strongly point to recent delivery.

II. Signs of Recent Delivery in the Dead.

Should the woman die immediately after delivery, the external parts will present the same appearance as just described in the living. On opening the abdomen, the uterus will be found flat and flabby, between nine and twelve inches long, and with the *os uteri* wide open. The cavity of the uterus may contain large bloody coagula, and its inner surface lined by the decidua. The attachment of the placenta is easily detected by its dark colour, and by the semi-lunar openings of the arteries and veins on the surface of the uterus.

Of course all the appearances just described will be greatly modified by the time that has elapsed between delivery and death.

Delivery after Death.—The fœtus has been known to have been expelled from the uterus by the force of the gases generated by putrefaction. Dr Aveling, in a paper published in the "Obstetric Transactions," 1873, arrives at the conclusion that *post-mortem* delivery is possible even where no symptoms of parturition were noticed before death. He also thinks that the child may live *in utero* for some hours after the death of the mother.

Table showing the Size of the Uterus at Different Periods after Delivery.

Two to Three Days.—About 7 inches long and 4 inches wide.
Seven Days.—Between 5 and 6 inches long and 2 inches wide.
Fourteen Days.—From 4 to 5 inches long and $1\frac{1}{2}$ inches wide.
End of Second Month.—Normal size. $2\frac{1}{2}$ inches long and about 2 inches broad at the fundus.

Table giving Weight of the Uterus after Delivery.

Immediately after Delivery,	. .	22 to 24 ounces.
Within a Week,	. . . .	18 to 21 "
End of Second Week,	. . .	10 to 11 "
End of Third Week, .	. . .	5 to 7 "
End of Second Month,	. normal,	9 to 10 drachms.

(Heschl.)

3. Signs of a Previous Delivery.—1. *Marks on the Abdomen*, consisting in shining silvery lines, due to the distension of the skin. These may result from distension other than that the result of pregnancy—tumours, dropsy, etc.

2. *Marks on the Breasts*, similar to those appearing on the abdomen. These, in conjunction with the above, are important.

3. *Peculiar jagged condition of the os uteri*, felt by the finger. This condition may be the result of disease.

4. *Marks of rupture of the fourchette or perinæum.*

5. *Dark colour of the areola round the nipples.*

6. *Negative evidence*, from absence of any of the above.

Can a Woman be delivered unconsciously?—This question may arise in cases of infanticide. Setting aside cases of epilepsy (in a fit of which disease I once attended a woman who was confined during the fit without being aware that she had been delivered), cases of apoplexy, coma, and narcosis from chloroform, opium, etc., it may be stated that delivery is possible during profound sleep. I once attended a woman who informed me that "she always had her pains during her sleep," and only woke up just as the head came into the world. When it is borne in mind how easily some women pass through labour, it is quite possible that, after a busy day, sleep may be so profound as not to be disturbed by the pains of labour. In primipara the occurrence is more problematical. Women have often declared that they have been unconsciously delivered whilst at stool. This is also probable, but the circumstances of the case must be severely sifted.

FŒTICIDE, OR CRIMINAL ABORTION.

[*"Every woman, beiug with child, who, with intent to procure her own miscarriage, shall unlawfully administer to herself any poison or other noxious thing, or shall unlawfully use any instrument, or other means whatsoever, with the like intent: and whosoever, with intent to procure the miscarriage of any woman, whether she be or be not with child, shall unlawfully administer to her, or cause to be taken by her, any poison or other noxious thing, or shall unlawfully use any instrument, or other means whatsoever, with the like intent, shall be guilty of felony, and being convicted thereof shall be liable, at the discretion of the Court, to be kept in penal servitude for life, or for any term not less than five years, or to be imprisoned for any term not exceeding two years, with or without hard labour. and with or without solitary confinement."*—STATUTE 24 & 25 VICT., c. 100, sec. 58.]

The 59th section of the same Statute also takes into consideration the unlawfully supplying or procuring any poison, or other noxious thing, or instrument, or thing whatsoever for a woman, for the purpose of inducing abortion. The person so doing shall be guilty of a misdemeanour, and be kept in penal servitude for a term of five years, or be imprisoned for any term not exceeding two years, with or without hard labour.

It will be seen from the passages above quoted that there is no distinction between a woman *quick* or not *quick* with child. "The offence is to procure the miscarriage of *any woman, whether she be or be not with child*" (R. *v.* Goodhall, 1 Din. 187; 2 C and K 293). But although the law does not regard "quickening" in cases of abortion, yet the fact of having "quickened" may be pleaded as a bar to immediate capital punishment.

It has been decided in Scotland that drugging or operating to procure abortion is criminal, though unsuccessful, but it is not certain whether the woman alone can be charged with taking drugs to procure abortion. Both in England and in Scotland, to make the procuring of abortion criminal, "there must be felonious intent," for it may be necessary to cause abortion. It must be borne in mind that the law allows no discretionary power on the part of medical

practitioners who, to save the life of the mother, may deem it advisable to induce premature delivery. This being the case, no medical man should attempt to induce premature labour without the consent of the relatives of the woman, and the sanction of a medical colleague after consultation. This precaution is the more necessary as several medical men have of late years been prosecuted, an event which would not have taken place had the precaution above suggested been observed. A medical man should also be very careful never to give any medicine "to bring on the courses" if he has the slightest suspicion of pregnancy, even as a "placebo" to satisfy an importunate patient, for should abortion be otherwise procured, his really harmless medicine may be accused with the result, and a grave suspicion be raised against him, to say the least.

The term *abortion* is understood in *medicine* to mean the expulsion of the contents of the fœcundated uterus before the sixth month of pregnancy, that is, before the child is considered viable. After this period it is said to be a premature labour.

In law, however, no distinction is made, and the expulsion of the contents of the uterus at *any* period before the full time of pregnancy is considered an *abortion ;* in popular language, a *miscarriage.*

Abortion, when not produced by criminal means, generally occurs at or a little before the *third month* of utero-gestation, and then usually in first pregnancies, or during the latter part of the period of child-bearing. It is also more frequent among the rich than among the poor. Of the two thousand cases of pregnant women examined by Dr Whitehead of Manchester, the sum of whose pregnancies was 8681, or 4·38 for each, rather less than 1 in 7 had aborted.

When abortion is criminally induced, it generally takes place between the *fourth and fifth month*, that is, about the time the woman becomes certain of her condition.

The Causes of Abortion are—

1. Natural or Accidental.—(*a*) Maternal—belonging to the mother; (*b*) Fœtal—belonging to the ovum.
2. Violent. (*a*) Mechanical; (*b*) Medicinal.

I. NATURAL OR ACCIDENTAL.

1. **Maternal.** — Among the maternal causes may be mentioned excessive lactation; any irritation of the rectum or bladder; loss of blood, which, by increasing the amount of carbonic acid in the blood, acts as an excitant to the spinal cord; excessive irritability and excitability of the uterus, etc. Certain states of the system conduce to abortion — albuminuria, syphilis, certain fevers, scarlet, small-pox, etc. Abortion may become habitual in some women. Great joy or sudden sorrow have not infrequently been the cause of abortion. The tendency to abortion is greatest at the menstrual periods, that is, at the time when, had not the woman become pregnant, menstruation would have taken place. Slight causes acting at these times are very liable to produce abortion.

2. **Fœtal.**—The death of the ovum, or a diseased condition of its uterine coverings, or of the placenta, probably of an inflammatory nature.

2. VIOLENT.

1. **Mechanical.** — Under this head may be mentioned the passage of certain instruments into the cavity of the womb, and the rupture by violence of the membranes which surround the fœtus. A medical man practising in Yorkshire lately, informed me that so great was the dread of large families, that he knew of several ladies who if they went a day over their monthly period passed a catheter into the uterus with the desired

result. "It was wonderful," he added, "how clever they were." In India a twig of the *Euphorbium nivulia*, anointed with assafœtida is used for the same purpose. "The fœtus is never delivered alive, but there is said to be no great danger to the woman" (CHEVERS). In some cases it is by no means easy to procure abortion, and women have been known to undergo a considerable amount of violence without abortion taking place. In some women, however, on the other hand, the slightest violence—such, for instance, as slipping from a step or low chair—will cause them to abort.

2. **Medicinal.**—Certain drugs, among which may be mentioned ergot, savin, pennyroyal, and a host of others, have been used for the induction of abortion. In India unripe pine-apple has a great reputation as an abortive ("Medical Jurisprudence for India," CHEVERS). It is scarcely necessary to mention each drug individually, but it must be remembered, "that there is *not one single internal medicament* of which it can be consistently with experience asserted, that even when an abortion has followed its use, it must have produced this abortion, and that cause and effect are in such a case in direct and necessary connection." All the so-called *abortives* are most uncertain in their action, and their use is attended with considerable risk to the woman. Be this as it may, they are more frequently used to induce abortion than mechanical procedure, from the fact that the latter requires some amount of anatomical knowledge and manipulative skill, which in Yorkshire, if not elsewhere, appears to have been acquired.

A medical man may be required to—(1) Examine into the nature and characters of the substances expelled from the womb.—(2) Examine the woman stated to have aborted.

1. Examination of the Substances Expelled from the Womb.—The substances expelled from the womb often become the subject of judicial inquiry, and the medical man may be required to give his opinion as to their probable nature.

Dr Gallard has called attention to the following :—

1. During the last six months of pregnancy, abortion, even when it occurs spontaneously, goes through the two stages as at full time, *i.e.*, the expulsion of the products of conception is, as a rule, preceded by rupture of the membranes, followed after a time by the expulsion of the placenta.

2. In the first three months this order of things is absent, for it is the rule to see the fœtus expelled entire *en bloc* without rupture of the membranes.

3. If, then, we find during the first three months of pregnancy the products of an abortion in which the membranes have been ruptured and the embryo expelled alone, we must look for a pathological cause for this infraction of a general rule ; and if no disease of the embryo or of the mother is found, we are justified in attributing the abortion to mechanical means used directly against the products of conception. Charpentier has shown that this rupture of the membranes is not an absolute proof of criminal abortion ; but in eighteen cases of spontaneous abortion M. Leblond only found rupture of the membranes in one, and in this the membranes presented an abnormal friability.

The questions may be asked—(1) Is it a fœtus ?—(2) Is it a mole ? If so, is a mole also a fœtus ?—(3) Is it merely the coats of the uterus, and unconnected with pregnancy ?

1. *Is it a Fœtus ?*—The developement of the fœtus is given, page 169.

2. *Is it a Mole ?*—This question gives rise to another. Is a mole a fœtus ? To this the answer must be in the affirmative. Moles, being the diseased appendages of the fœtus, vary in character, and have been described by obstetrical writers under the following heads :—(*a*) Hydatiginous ; (*b*) Carneous ; (*c*) Fatty Moles.

(*a*) *Hydatiginous Moles* are a result of a diseased condition of the villi of the chorion. The villi become dropsical, and hang in masses like a bunch of grapes.

(*b*) *Carneous Moles.*—These are the result of hæmorrhage into the chorion. The blood becomes organised, and a fleshy mass is formed, to which in some cases a withered fœtus is attached.

(*c*) *Fatty Moles.*—Death of the fœtus and fatty degeneration of the placenta or fatty degeneration of the placenta and death of the fœtus, produces this variety of mole. A withered fœtus with a mass of fatty placenta are expelled.

3. *Is it merely the Coats of the Uterus, and unconnected with Pregnancy?*—Fleshy masses may be expelled from the womb, which may not be the result of sexual intercourse. The description just given of true moles will, it is hoped, assist in forming a correct diagnosis. Considerable care will be required, for the honour of the woman accused depends upon the opinion given as to the nature of the substances submitted for examination. It must also not be forgotten that moles may be retained for many months in the uterus, and be then expelled. The knowledge of this fact may rebut an accusation of infidelity against a wife. Polypi may be discharged from the womb; the presence of a pedicle will point to their true character. All substances expelled from the uterus should be carefully washed in water, and all clots removed. The examination of the woman may also help in the formation of the diagnosis. The absence of the signs of defloration or of recent delivery will be in her favour.

2. Examination of the Woman stated to have aborted.—This subject may be divided under two heads—(1) Has the woman been recently delivered?—(2) What are the means used to procure the abortion?

It is by no means easy to answer the question whether an alleged abortion has really taken place or not. The signs of recent delivery are in most cases absent, for the woman can better hide her condition during the earlier

than during the later months of utero-gestation; consequently suspicion may not have been aroused against her for some weeks or months after the event. The history of the case, with other attendant circumstances—milk in the breasts, change in the colour of the areola round the nipples, severe flooding, absence of the hymen, injuries to the os uteri, transverse condition of the os uteri in contradistinction to its circular form after delivery, etc.,—will, in most cases, assist in forming a correct diagnosis; but it must be again repeated that few of the signs applicable to delivery at the full time are here available.

In all doubtful cases—

1. Examine into the general and present state of the health of the woman.
2. Find out if there are any reasons which would occasion a pretext to use drugs which are not usually given to women during pregnancy.
3. Learn if menstruation is regular and easy, or if the woman is in the habitual use of emmenagogues, for, if so accustomed, she may have used them ignorant of pregnancy.
4. If a woman ascribes her abortion to a fall, to an accident, or to violence used against her, carefully examine into the nature of these.
5. Examine into the general causes of abortion, and also inspect the expelled substances.

Where death is supposed to have followed the use of abortives, the alimentary canal must be examined for the signs of the action of irritants, or the presence of disease in the internal organs; but when death has resulted from an attempt to procure abortion by instrumental means, the neck of the womb is most frequently found covered by a number of small more or less irregular wounds, which may penetrate into the womb or lose themselves in the walls of the organ. Their course is indicated by infiltration, or a small extravasation of coagulated blood, the exact condition of which must, if possible, be ascertained, so as to decide when the wound was inflicted.

The examiner must not forget that the wounds may extend to the fundus of the uterus, and in this case the autopsy shows that a blunt instrument, as a catheter or uterine sound, introduced through the os uteri into the retroverted uterus, glides by its own weight into the rent. The seat of the tear leads one to think that pregnancy was not far advanced when the attempt was made, and in fact the accident most frequently occurs in cases of suspected pregnancy. It must be remembered that the uterus is often punctured by the injudicious use of the uterine sound, but without any immediate dangerous symptoms. Wounds in the walls of the vagina indicate the use of instruments by an inexperienced hand; in the fundus of the uterus, to one at least accustomed to the introduction of instruments. Spontaneous rupture of the uterus is impossible during the early periods of pregnancy, just when the attempts at abortion are usually made. Rupture due to external violence is, as a rule, accompanied with outward signs of the violence used.

In all cases a careful examination of the structure of the uterus should be made. An examination of the ovaries for *false* or *true corpora lutea* should be made. The opinions on the character and differences of these bodies are so discordant as to destroy all confidence in their value as proof of conception or the reverse.

Taylor says: "The discovery of the *ovum* in the uterus *in process of development* could alone, in the present state of our knowledge, warrant an affirmative opinion on this point in a Court of Law, and this I believe to be the safest view at present of this much-contested question. On the other hand, the absence of a corpus luteum from the ovary would not in all cases warrant an opinion that conception had not taken place."

RECAPITULATION.

In Medicine, Abortion occurs before the sixth month of pregnancy—premature labour after that period.

In Law, Abortion may take place any time before the full period of utero-gestation.

Abortion may be due to—

1. *Natural or Unavoidable Causes.*
   (*a*) Maternal. (*b*) Fœtal.
2. *Violence, with Criminal Intent.*
   (*a*) Mechanical, (*b*) Medicinal.

INFANTICIDE.

According to the present state of English law, infanticide—murder of a *new-born* child—is not regarded as a specific crime, but is treated and tried by those rules of evidence which are applicable in cases of felonious homicide, but with this difference, that the law requires proof that the child was born alive. An old Statute (21 J. 1, c. 27) made the concealment of the birth of a bastard child conclusive evidence of murder. As far as the legal estimation of the crime is concerned, it matters not whether the child was killed immediately on its entrance into the world, or within a few days afterwards. A fœtus not bigger than a man's finger, but having the shape of a child, is a child within the Statue (R. *v.* Colmer, 9 Cox 506; R. *v.* Hewitt, 4 F. and F. 1101). An English Judge, at a late trial, stated that if the Jury were of opinion that the prisoner had strangled her child before wholly born, she must be acquitted of murder. The law also, on the score of humanity, presumes that every child is born dead until direct evidence to the contrary, from medical or other sources, is given. The onus of the proof of live birth, therefore, devolves on the prosecu-

tion. It may also be difficult to decide as to the maternity, and the woman accused will have to be examined as to the possibility of her recent delivery.

Here let me repeat the advice given on page 129 as to the examination of women. Your duty is to request the woman to allow of the necessary examination, giving her the warning which every magistrate or coroner is bound to give to any person charged with a crime, before requiring an answer to a question which may be used in evidence against her at the subsequent trial. The innocent and the guilty may alike object to an examination, but the presumption is against the party declining, if several have voluntarily submitted. A young lady committed suicide rather than submit to an examination by two medical men under an order from the coroner. The medical men were guilty of a grave indiscretion, and both they and the coroner were acting *ultra vires* in attempting to force a woman to obtain evidence against herself (TAYLOR, vol. ii., page 431). The decision as to recent delivery will, to a great extent, rest on the condition of the mother, and the apparent age of the child found dead. The discovery of the body of the child is not necessary to conviction, but the medical evidence as to the signs of respiration, of course, depends on the body being found and examined. In most cases of alleged infanticide tried in England, Juries appear more inclined to fall back on the minor offence—*concealment of birth*—than to convict of the capital offence; and this appears to be the only alternative if the body cannot be found, for, as we have just said, in law every child is held to be born dead. It must of course be shown that the woman has been recently delivered. In case of failure to prove the murder of the child, the Act (24 and 25 Vict., c. 100, sec. 60) enacts that "if any woman shall be delivered of a child, every person who shall, by any secret disposition of the dead body of the said child, whether such child died before, at, or after its birth, endeavour

to conceal the birth thereof, shall be guilty of a misdemeanour." The mere avowal of the birth is not sufficient to convict her; she must be proved to have done some act of disposal of the body after the child was dead (R. *v.* Turner, 8 C. & P. 755).

In Scotland, *concealment of pregnancy* is a statutory crime, chargeable when the child born is found dead or is not found at all, and there is no proof of its having been murdered. Pregnancy, up to a period when a child might be born alive, must be proved, and the words "during the whole period of her pregnancy" do not imply that the pregnancy must have continued for the full period of nine months. All that is necessary is that there should be such proof of duration of pregnancy as made a living birth possible. If the accused can bring forward a witness to whom she communicated her pregnancy, or called for assistance at the birth, or (it is believed) can prove that the child was born dead, she is entitled to an acquittal. It has also been said that a woman ought not to be convicted of "concealment of pregnancy," if at the time of delivery the fœtus do not appear to have reached the seventh month of intra-uterine existence. The birth of a "child," whether dead or alive, is essential; therefore, if the woman accused "can prove that that which she brought forth was not a 'child,' but an abortion, or a *fœtus*, which, from some accident, was in such a condition that, though there had been assistance, it could not have been in a condition to be called 'a child,' then the case is out of the Statute." The Scotch Statute differs from the English on the "concealment of birth" in this, that so long as the woman makes known her pregnancy, the motive for doing so is not considered. Thus, if she make arrangements with any one to conceal the birth, "the Statute is eluded by that very circumstance" (Alison). The Statute applies to married as well as to single women; but, in the former case, the penalty is seldom enforced unless foul play is suspected.

DEFINITION OF THE TERM "LIVE BIRTH" IN CRIMINAL CASES.

The entire delivery of a child." There must be an independent circulation in the child before it can be accounted alive. (R. *v.* Enoch, 5 C. & P. 539.) The entire child must be actually born into the world in a living state. (R. *v.* Poulton, 5 C. & P. 329.) But the fact of the child being still connected with the mother by the umbilical cord will not prevent the killing from being murder. (R. *v.* Reeves, 9 C. & P. 25.) To kill a child in its mother's womb is no murder, because the person killed must be "a reasonable creature in being, and under the King's peace." But if the child be injured in the womb, and yet be born alive, and then die as a result of such injuries, it may be murder in the person who inflicted them. (R. *v.* Senior, 1 Mood. C. C. 346.)

A distinction must be drawn between *medical or physiological life* and *legal life.* A child may have breathed, as it not infrequently does, *before* it is completely born into the world; and this might, in a medical point of view, be considered as a live child, but it is not one legally. The entire delivery of the child is necessary in law; and "it must also be proved that the entire child has actually been born into the world in a living state, and the fact of its having breathed is not a conclusive proof thereof." The inference unfortunately follows from this ruling, that a mother may kill her child without fear of punishment, if she do so before the entire body has slipped from her.

DEFINITION OF THE TERM "LIVE BIRTH" IN CIVIL CASES.

The evidence of live birth in civil is somewhat different to that required in criminal cases. The

viability of the child is determined in Scotland by its *crying*; in France, by its respiration; in Germany, "the LIVE BIRTH of a child is to be held proven when it has been heard to cry by witnesses of unimpeachable veracity present at its birth;" but in England, the pulsations of the child's heart, or any tremulous motion of the muscles, however slight, have been considered as satisfactory proof of live birth.*

According to Blackstone, "crying, indeed, is the strongest evidence, but it is not the *only* evidence; and Coke remarks, "If it be born alive, it is sufficient though it be not heard to cry, for peradventure it may be born dumb."

Signs of Live Birth prior to Respiration, and independent of it.—(1) Negative.—Signs of intra-uterine death, *i.e.*, putrefaction, or "intra-uterine maceration," or of such imperfect development that it could not have been born alive.—(2) Positive—Injuries to the child showing that it must have been born alive.

1. NEGATIVE. — *Intra-uterine Putrefaction.* — This condition differs in some remarkable points from putrefaction in air.

The body is extremely flaccid and flattened, the bones of the cranium moving easily on one another. The skin of the hands and other parts of the body bear the evidence of prolonged soaking in fluid. In parts, the skin is whitish, or of a reddish-brown or coppery-red colour, without any trace of green, which is always present when putrefaction takes place in the air. The cuticle may be raised in blisters, and be easily detached from the true skin. The denuded patches are moist and greasy, and exude a stinking, reddish-coloured serous fluid. The

* Fyshe or Fisher *v.* Palmer, in 1806.

face is flattened, and the features distorted. In one case that I attended of intra-uterine death of the fœtus in a primipara, and where putrefaction was far advanced, the scalp burst during delivery, and the brain was poured out. Should, however, the child be exposed to the air, it may soon acquire the appearances proper to putrefaction in that medium. If the child, immediately after birth, be thrown into water, the putrefactive changes would be like those of intra-uterine decomposition. In this case, the lungs must be examined for the evidence of death by drowning.

2. Positive.—Evidence that injuries found on the body could not have been inflicted during birth, or accidentally after birth. On this subject it is scarcely possible to give an opinion one way or the other. All the medical witness can fairly state is, that, from the condition of the lungs, respiration has or has not taken place; that, in the former case, it is not easy to state whether the injuries were the cause of death or inflicted after death.

Appearances showing that a New-Born Child has Breathed.—1. Walls of the Chest.—"The vaulting of the thorax is not of the slightest diagnostic value." Casper quotes from Elsässer the following remarks:—"It is irrefutable that the variations in the circumference of the thorax (and, of course, in its diameters) are so considerable that no certain normal mean for a thorax that has breathed, and for one that has not breathed, can be laid down. In most cases the measurements of the thorax are incapable of determining whether the lungs contain air or not. The reason for these variations is, without doubt, to be referred to the congenital differences in the volume of the osseous thorax; partly, also to the thickness of the soft parts, particularly of the subcutaneous fat and the thoracic muscles; partly, also, in the differences in the degree

and amount of the dilatation of the thorax by respiration, with which the distension of the lungs also corresponds," etc.

2. Diaphragm.—The position of the diaphragm may be considered as a good diagnostic sign; for it is found that, in children born dead, the highest point of the concavity is between the fourth and fifth ribs, whereas in those born alive it is between the fifth and sixth. The position of the diaphragm may be affected by the gases produced during putrefaction, and also, in children who have *breathed*, from distension of the stomach and intestines with gas.

3. Stomach and Intestines.—With regard to the stomach, Tardieu has suggested that the presence of air-bubbles in the glairy mucus usually found in that organ is a sign of live birth, as it can only have arisen from the swallowing of saliva and mucus, aerated by repeated attempts at respiration, probably lasting from five to fifteen minutes. Breslau of Prague, who has further investigated this subject, states that, in children born dead, or who have undergone prolonged intra-uterine putrefaction, there is never any accumulation of gas in the stomach or intestines, and that the presence of gas in these organs is contemporaneous with respiration, and is independent of the ingestion of food. The intestines of newly-born children do not float in water, but rapidly sink in that fluid. As respiration proceeds, the coils of the intestines become distended with gas.

4. Kidneys and Bladder.—The presence of crystals of uric acid in the pelvis of the kidneys and even in the bladder has been suggested as a sign of live birth. Uric acid infarction, as it has been called, usually occurs in from two to ten days after birth, at a period when there are more important signs of live birth than this, even if infarction did not occur, as it does, in still-born infants.

5. Lungs.

(*a*) *Size.*—In the fœtus, prior to respiration, the lungs do not fill the cavity of the chest, and the left lung is never found even partially covering the heart.

After respiration they fill the thorax more or less completely, the amount of distension depending, of course, upon the completeness of the respiratory acts on the part of the child.

(*b*) *Consistence.*—Before respiration has taken place, the lungs feel firm, compact, and resistant, and are of the consistency of liver.

After respiration they are spongy, crepitant, and yielding when pressed between the fingers. They also present a marbled appearance. These signs of respiration are more or less modified by disease, and the *atelectasis pulmonum* of Jörg, jun.

Casper denies the existence of *atelectasis pulmonum* as a distinct disease of newly-born children, and considers that "it is nothing else than the original fœtal condition, from which it differs in no anatomical respect" —an opinion supported by Meigs, who says, "they, in fact, resemble exactly the fœtal lung." It is simply the result of the child dying from some cause before respiration has had time to become fully established, and has possibly been confounded with hepatisation. It must also be remembered that cases are on record of infants having lived for some hours, and then died, and yet the lungs sank as a whole, and when cut in pieces.

(*c*) *Colour.*—The colour of the fœtal lungs is "exceedingly various," and it is by no means easy to convey the idea of colour by words. Speaking in general terms, the lungs of children who have *not* breathed are of a reddish-brown liver-colour, this colour changing to a brighter red at their margins. In children who *have* breathed, the lungs are of a slaty-blue colour, more or less mottled with circumscribed red patches. This circumscribed mottling is *never* found in perfectly fœtal

lungs. When the lungs are inflated artificially, they swell up and present a uniform cinnabar-red colour, destitute of insular marbling. The insular marbling of the lungs is characteristic of lungs that have breathed, and is due to the presence of blood in the arteries and veins surrounding the inflated lung tissue.

(*d*) *Buoyancy in water.*—Lungs which have respired float in water.

But the objection may be raised that lungs that have *not* respired may yet float from—

1. The result of artificial respiration.
2. The result of putrefaction.

The value of these objections will be discussed in the following pages.

THE FOLLOWING TABLE IS GIVEN BY TIDY :—

LUNGS THAT HAVE NOT BREATHED.	LUNGS WHICH HAVE BREATHED.
1. Dark in colour (black-blue, maroon, or purple) resembling liver. No mottling.	1. Light in colour (rose-pink, pale-pink, light-red, or crimson), mottled.
2. Air-vesicles not visible to the naked eye.	2 Air-vesicles distinctly visible to the naked eye, or a lens of low power (say a two-inch, or even a common reading glass).
3. When squeezed or cut, do not crepitate or crackle.	3. Crepitate or crackle freely.
4. Contain but little blood, therefore little escapes on section.	4. Contain a good deal of blood, which escapes freely on section.
5. The blood present is not frothy, unless there be putrefaction.	5. This blood is freely mixed with air, and therefore appears frothy.
6. Sink in water, unless putrid, and often not then.	6. Float in water; or, at all events, the parts which have been expanded, or have breathed, float. If fully expanded, they will buoy up the heart.
7. Bubbles of gas arising from putrefaction may be squeezed out, and as they escape are usually noted to be of large size.	7. The air cannot be squeezed out by pressure.

Hydrostatic Lung Test.

(Docimasia pulmonum hydrostatica.)

The value of this test, which is a test of respiration and not of live birth, is founded on the supposition that a lung in which respiration has taken place will float if placed in water, and that when this has not occurred it will sink. Admitting that a lung floats as a result of respiration, it has been objected that this is no proof of live birth, for respiration may take place in—

1. The womb, *vagitus uterinus.*
2. The maternal passages, *vagitus vaginalis.*
3. Cases when the head protrudes, the body not yet being born.

With regard to the two first objections, it will be sufficient to say that, in all the cases of so-called intra-uterine respiration, the respiratory acts have occurred in difficult or instrumental labours, where it is justifiable to suppose that, in the endeavour to remove the child, a certain amount of air may have been unavoidably admitted into the maternal passages. But the cases with which the medical jurist has to deal cannot be classed with these, for in all those brought under his notice delivery has been more or less rapid and unassisted.

To the last objection the same reply may be given, that rapid delivery in doubtful cases must be considered as the rule, and that the time which elapses between the birth of the head of the child and its complete delivery is so short as not to lead to any great error in diagnosis. It is true that the woman may faint with the child half born, and that respiration may thus take place; and it has not yet, as far as I know, been decided how many inspirations a child must make to entirely inflate its lungs, or the length of time required to do so.

N.B.—Any pressure exerted on the umbilical cord during the process of delivery gives rise to respiratory acts on the part of the fœtus. The presence of what Casper calls *petechial ecchymoses* beneath the pleuræ, upon the aorta, and even on the heart, are, as a rule, a proof that attempts at respiration have been made. These petechial ecchymoses are sometimes found on the same parts in the drowned. (See "Drowning.")

How is the Hydrostatic Lung Test Performed? and What are the Objections to its Use?

As this test was first used, it consisted in placing the lungs, with or without the heart, in water, and then noting whether they sank or floated. A glass vessel, eighteen inches high and twelve in diameter, half filled with distilled water at 60° F., should be used. In summer, water at the ordinary temperature of the room will answer the purpose. To this rough test pressure is now added; the lung, or portions of it, are greatly compressed in a linen cloth, and then thrown into water as before. If the lungs thus compressed float, respiration is held to have taken place; should they sink, the contrary is presumed.

Pressure is used for the following reason:—The air generated by putrefaction, and which may cause the lungs to float, is removed by pressure, but no amount of pressure short of entirely destroying the lung tissue will remove that, the result of respiration or inflation; and between these the medical expert must decide from collateral evidence.

In performing the test—(1) Try if the lungs will float with the heart and thymus gland attached to them. (2) If they will float without the heart, etc. (3) Try if portions will float with or without pressure.

THE FOLLOWING ARE THE OBJECTIONS TO THIS TEST—

1. The lungs may sink as a result of disease.
2. Respiration, even in healthy lungs, may be so imperfect that they may sink.
3. Emphysema pulmonum neonatorum.
4. Putrefaction.
5. Artificial inflation.

1. That in consequence of disease the entire lungs or portions of them may sink, and yet respiration may have taken place. Disease of the lung may occur previously to birth or soon afterwards, but it is scarcely probable that the disease would attack every portion of the lung. Parts, doubtless, small in proportion to the diseased part, may yet have been sufficiently inflated to float. The presence of disease is also not difficult of detection.

2. That respiration, even in healthy lungs, may be so imperfect that they may sink. This objection can scarcely be considered valid against the general application of the test, for in these cases there is no known test by which respiration or its absence can be determined. They are, therefore, out of the pale of the test, as they are out of every other mode of investigation.

3. *Emphysema pulmonum neonatorum.*—Emphysema is generally the result of excessive dilatation of the air cells of the lung, rupture of the cell walls, and infiltration of the intra-lobular areola tissue. This condition may be brought about by—

(*a*) Respiration. (*b*) Inflation.

The fact of the matter is simply this, that the so-called *emphysema pulmonum neonatorum*, or emphysema of new-born children, is nothing more or less than incipient putrefaction, induced by certain unascertained conditions.

Casper sums up his conclusions on this subject in the following words :—"That not one single well-observed and incontestable case of emphysema, developing itself spontaneously within the lungs of a fœtus born without artificial assistance, is known; and it is not, therefore, permissible in forensic practice to ascribe the buoyancy of the lungs of new-born children, brought forth in secrecy and without artificial assistance, to this cause."

4. *Putrefaction.*—It must be admitted as proved that the lungs of new-born children in a state of decomposition will float in water. But this admission does not render the test valueless, for it must be remembered—

(*a*) That air generated by putrefaction is found in bubbles *under* the pleuræ, or in the fissures between the *lobuli* of the lungs, and *not in the air cells* of the lungs.

(*b*) That air as a result of putrefaction can readily be removed by compressing the lungs or portions of them.

(*c*) That crepitation in putrefied lungs is absent, owing to the fact stated under (*a*).

(*d*) That the lungs are among those organs which putrefy late.

(*e*) That negative evidence may be obtained, if the lungs, in a highly putrescent body, sink in water. The tendency of putrefaction, as above stated, is to cause them to float.

5. *Inflation.*—In the first place, it is to be remarked that to inflate the lungs is by no means an easy task. Elsässer states "that in forty-five experiments performed on children born dead, without opening their thorax and abdomen, only *one* was attended with complete success, thirty-four with partial success, and ten with none whatever; and it must also be remembered that these experiments were conducted without disturbance, and with the greatest care." Professor Gross states his opinion on this subject thus :—"We are decidedly of opinion that artificial inflation of the lungs is a very difficult matter; and we believe that the complete distension of these organs can only be effected where a tube is introduced into the mouth of the larynx." An

old pupil once told me that in trying artificial respiration on a still-born child, he desisted from his attempts at resuscitation on finding the air, which he hoped was entering the lungs, escaping from the anus. In the cases that come before the medical expert, the question naturally arises, Who would inflate the lungs? Surely not the mother, who would be only too glad that the child was dead, and who would be in no hurry to resuscitate it. If not the mother, who else? It has been suggested that some malicious person might inflate them to sustain a charge of infanticide. Is this probable?

The following points may be noticed on this subject:—

(*a*) Known difficulty in inflating the lungs.

(*b*) Absence on the part of the mother of any preparation to save the life of her child.

(*c*) Presence of air in the stomach and intestines, the result of attempted inflation.

(*d*) Bright cinnabar-red colour of the lungs, without trace of mottling.

(*e*) Absence of frothy blood when the lungs are cut into.

(*f*) "When, therefore, we observe the following phenomena, a sound of crepitation without any escape of blood-froth on incision, *laceration* of the pulmonary cells with hyperæria, bright cinnabar-red colour of the lungs *without any marbling*, and perhaps *air* in the (artificially inflated) stomach and intestines, we may with certainty conclude that the *lungs have been artificially inflated*."

It may be further noted that natural respiration is accompanied with, first, the distension of the air cells of the lungs with air; and, second, with an increased flow of blood into the organs beyond that necessary for their nourishment and growth. They thus increase in absolute weight, while their specific gravity is lessened.

The objections just mentioned apply to the hydrostatic test, as originally employed. It will now be necessary to notice those against the same test when modified by pressure. These are two in number:—

1. That no amount of pressure, short of entirely destroying the lung tissue, can expel the air from a

lung that has been inflated, or from one in which respiration has taken place.

2. Pressure is, therefore, no test of natural respiration or of artificial inflation.

In answer to the above, it will only be necessary to refer to what has been already said with regard to the difficulty of inflation, and the more probable event of the condition of the lungs being the result of respiration.

Casper thus sums up the result of his views with regard to the probative value of the *docimasia pulmonaris*:—

"*That a child has certainly lived during and after its birth.*

1. When the diaphragm stands between the fifth and sixth ribs.

2. When the lungs more or less completely occupy the thorax, or at least do not require to be sought for by artificial separation of the walls when cut through.

3. When the ground colour of the lungs is broken by insular marblings.

4. When the lungs are found by careful experiment to be capable of floating.

5. When a bloody froth flows from the cut surface of the lung on slight pressure."

THE LUNG TEST IS UNNECESSARY WHEN—

1. The umbilical cord has dropped off, and cicatrisation has followed.

2. Where food is found in the stomach.

3. Where there are evident signs of putrefaction *in utero*.

4. Also in the case of the birth of monsters, or where, from congenital malformation, the possibility of live birth is excluded.

Besides the hydrostatic test, the following have been proposed :—

Ploucquet's Test.—This test is based on the relative weight of the lungs, before and after respiration, to that of the entire body of the child. The variations found in practice between the relative weights render the test worse than useless.

Absolute Weight of the Lungs.—This test consists in a comparison of the weight of the lungs before and after respiration, and it may be stated here that the lungs, prior to respiration, vary in weight from about 400 to 650 grains; but so much depends on the maturity or immaturity of the child, and degree of respiration, that, like the last, the test is unworthy of confidence.

Wredin's Test.—Dr Wredin, of St Petersburg, states that the gelatinous substance found in the middle ear of infants before birth, gradually disappears, to be replaced by air on the subsequent establishment of respiration. Wendt, of Leipzig, from an examination of 300 cases, declares that the gelatinous substance can only be expelled by the establishment of full respiration. The value of this test has been questioned, as some observers have found that an interval of from a few hours to five weeks have occurred, to effect the replacement of the gelatinous material by air.

TABLE SHOWING THE DEVELOPMENT OF THE EMBRYO ACCORDING TO THE LUNAR MONTHS.

MONTH.	LENGTH.	WEIGHT.	OBSERVATIONS.
First. (3rd or 4th week.)	Four to Six lines.	Twenty grains.	The embryo is curved; the mouth on the cephalic extremity appears as a cleft, and the eyes as two black points. Nipple-like protuberances mark the position of the extremities. The heart can be seen, and the liver is disproportionably large.
Second. (End of 8th week.)	Fifteen to Eighteen lines.	Two or Five drachms.	The head disproportionably large. Nose, lips, and external parts of generation visible, but sex doubtful. Anus appears as a dark point. Abdomen encloses the internal organs. Extremities project slightly from the trunk. *Ossification* in *clavicle* and *lower jaw* about end of *seventh week;* in *frontal bone* and *ribs* towards end of *eighth week.*
Third. (End of 12th week.)	Two to Two-and-a-half inches.	One to Two ounces.	Eyes and mouth closed. Fingers well separated; nails recognisable. The sex can be detected by the aid of a lens. Supra-renal capsules and thymus gland are formed. The cavities of the heart and divisions of the brain distinct. The placenta isolated; the umbilical vesicle, allantois, etc., have disappeared.
Fourth. (End of 16th week.)	Five to Six inches.	Two-and-a-half to Three ounces.	The skin rosy and tolerably dense. Sex seen without aid from lens. The mouth is large and open; the umbilicus is near the pubis. Meconium of a greyish-white colour in the large intestines.
Fifth. (End of 20 weeks.)	Ten to Eleven inches.	Seven to Ten ounces, varying in individuals.	From the fifth month the length of the fœtus in inches is approximately *exactly double the number of the lunar months.* The nails are distinct. The head, liver, heart, and

TABLE SHOWING THE DEVELOPMENT OF THE EMBRYO—*Continued.*

MONTH.	LENGTH.	WEIGHT.	OBSERVATIONS.
			kidneys are disproportionably large. The hair appears as a light down. The meconium is of a yellowish-green colour. Points of ossification, pubis and os calcis.
Sixth. (End of 24th week.)	Twelve to Thirteen inches.	One to Two pounds.	Down and sebaceous matter cover the skin. The colour of the body is a cinnabar-red, and the umbilicus is further from the pubis, The meconium is darker in colour; and the scrotum is empty, the testes being close to the kidneys. The pupillary membrane is still present.
Seventh. (End of 28th week.)	Fourteen to Fifteen inches.	Three or Four pounds.	The skin is of a dirty red colour; the hair about half-an-inch long, and plentiful. Membrana pupillaris disappearing: eyelids non-adherent. The large intestine quite full of dark olive-green meconium. Fontanels distinctly felt. Liver still large, of a dark brownish colour.
Eighth. (32nd week.)	Fifteen to Sixteen inches.	Three to Five pounds.	The skin, covered with soft hair, is more of a rosy-flesh colour. Disappearance of the pupillary membrane, and descent of the testicles into the scrotum. The open vulva exposes the clitoris to view. The nails almost reach the tips of the fingers.
Ninth. (End of 36th week.)	Sixteen to Eighteen inches.	Six pounds.	The head covered with hair; the down on the body disappearing. The scrotum corrugated, and the vulva closing.
Tenth. (40 weeks.)	Eighteen to Twenty inches.	Seven to Nine pounds.	Well-known signs of maturity.

TABLE GIVING THE MEASUREMENTS, ACCORDING TO THE MONTHS, OF THE EXTREMITIES OF THE FŒTUS IN THE ORDER OF THEIR DEVELOPMENT.

	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Full Period.
Humerus	3½ lines.	8 lines.	13-15 lines.	16 lines.	20-22 lines.	23-24 lines.	3 inches.
Radius	2½ "	8 "	12 "	16 "	17 "	18-19 "	2 " 8 lines.
Ulna	3 "	8 "	13 "	17 "	18 "	22-23 "	2 " 10 "
Femur	2-3 "	4-5 "	12 "	17 "	19-21 "	24 "	3 " 6 "
Tibia	2-3 "	4-5 "	12 "	17 "	19-21 "	21-23 "	3 " 2 "
Fibula	2½ "	....	12 "	17 "	19-21 "	21-23 "	3 " 1 "

TABLE SHOWING THE MAXIMUM AND MINIMUM DIMENSIONS OF THE OSSEOUS NUCLEUS OF THE INFERIOR FEMORAL EPIPHYSIS FROM THE SEVENTH MONTH OF INTRA-UTERINE LIFE TO TWO YEARS AFTER BIRTH.

	INTRA-UTERINE.			EXTRA-UTERINE. Days.			EXTRA-UTERINE. Months.			
	Seventh.	Ninth.	Mature.	1-8	9-15	16-28	1	3-6	7-12	12-24
Maximum	....	2 lines,	4 lines.	3½ lines.	3½ lines.	2½ lines.	5 lines.	4 lines.	8 lines.	7 lines.
Minimum	....	....	¾ "	1 "	¾ "	1½ "	2 "	2 "	3 "	5 "
No. of Children Examined 125	31	9	52	8	3	2	9	3	6	2

Table showing the Signs of Maturity of Child at Birth.

As regards—

1. *Average Length of Body.*—Nineteen inches.
2. *Average Weight of Body.*—About seven pounds.
3. *Eyes.*—The pupillary membrane is not found in the mature child.
4. *Navel.*—Said to be exactly midway between the pubis and the ensiform cartilage.
5. *External Genitals.*—Testicles found in the scrotum, and the labia majora cover the vagina and clitoris.
6. *Os Femoris.*—Ossification of the inferior femoral epiphysis. The osseous nucleus measures from three-quarters of a line to three lines in diameter.

CAUSE OF DEATH TO THE FŒTUS.

Death may be due to—

I. Immaturity on the part of the Fœtus.
II. Complications occurring during or immediately after Birth.
III. Congenital Disease in one or more of the Fœtal Organs.
IV. Neglect or Exposure, constituting "Infanticide by Omission."

I. Immaturity on the part of Fœtus.—From some cause or another, the child may die immediately after birth, in spite of every attempt to save it. In many of these cases no disease adequate to account for death can be detected.

II. Complications occurring during or immediately after Birth.—(1) Unavoidable or inherent in the process of parturition. (2) Induced with criminal intent, constituting "infanticide by commission."

1. *Unavoidable or Inherent in the Process of Parturition.*—The immediate cause of death may be either maternal or fœtal. In the former, the presence of tumours in the pelvic passages, or disease of the bones, causing a narrowing of the canal, may lead to fatal compression of the head of the child. Death may also be due to protracted labour from debility on the part of the mother, or she may suddenly faint after delivery.

A congested state of the brain may be present in these cases. In the latter (fœtal), pressure on the umbilical cord from mal-position of the child during labour, or an abnormal increase in the size of the head, may cause death. There is also a greater mortality, both during and after delivery, among male than female children. The child may be also accidentally suffocated in the fæces of the mother, or in a fold of her dress ; or it may be born while the woman is straining at stool, and be drowned in the contents of the pan. The writer once met with a case of accidental death of a child from suffocation in the drawers of the mother, who persisted, from motives of delicacy, in wearing those articles of dress during her confinement. Death may also result from strangulation, occasioned by the pressure of the funis round the child's neck. The death in this case can scarcely be considered as due to strangulation, as the child had never breathed, but it is probably the result of the arrest of the flow of blood along the cord, from the tightness of the folds round the neck. Some congestion of the brain may, however, be found resulting from the pressure on the vessels of the neck. Lastly, death may ensue from a fall on the floor in cases of sudden and quick labours, especially if the woman be in the erect posture at the time of delivery.

2. *Induced with Criminal Intent.*—Infanticide by commission, was the death due to violence? The answer to this question is by no means easy. In all doubtful cases the attendant circumstances must be taken into consideration. A woman may unintentionally injure her child in her efforts to drag it from her. The presence of respiration, more or less complete, is strongly presumptive against the death being the result of accident. But even here considerable caution is necessary, for the injury may not be immediately fatal, although accidentally inflicted, sufficient time elapsing between its infliction and the death of the child to allow of respiration. Foreign bodies found in the

mouth and fauces is also corroborative of death by violence. A case is recorded in which the child's fauces, upper portion of the œsophagus, the larynx, and the trachea were closely packed with a coarse green sand, and yet the lungs sank when the hydrostatic test was applied to them. No light was ever thrown as to when the packing of the fauces was effected. If dead, Why? If alive, How was respiration prevented during the operation? Strangulation may be produced by the constriction of the umbilical cord round the neck, and for this reason marks round the child's neck cannot always be ascribed to intentional violence. Of 327 cases collected by Elsässer, in which the cord was from one to four times round the children's necks, there was not in a single instance any mark of the cord perceptible, even though in some cases the cord has to be cut to permit the completion of labour. With regard to marks round the neck of a new-born child, Casper remarks that it is possible "to mistake the folds of the skin, produced by the movements of the head, and which remain strongly marked in the solidified fat, and are very prominent, particularly in short necks, for the marks of the cord." The *mark* left by the *funis* is broad, corresponds with the breadth of the cord, runs without interruption round the neck, and is everywhere quite soft, and never excoriated. Ecchymoses may be present, irregularly following the line made by the cord. On the other hand, "a mummified, parchment-like, unecchymosed depression points in every case to strangulation by a hard rough body," and this more especially if there be any abrasion of the cuticle or laceration of the skin. Death, sometimes ascribed to strangulation, is probably the result of suffocation, and happens thus: any pressure exerted on the cord cuts off the blood from the placenta to the fœtus, and gives rise to respiratory attempts on the part of the child, and the child dies from suffocation, or from the engorgement of the lungs with liquor

Lungs and Thoracic Viscera of a newly-born full term child, which has breathed, the victim of criminal suffocation, showing the punctiform disseminated ecchymoses under the pleuræ and pericardium and on the surface of the thymus body; typical of the alterations characteristic of this kind of death.—*After Tardieu.*

amnii drawn into them at every effort to breathe. An infant may be poisoned. This cause of death is very rare, but deaths have resulted from the use of poisonous gases. While on this subject it may be advisable to state here, that ulcerations have been found in the stomach and intestines more or less accompanied with a collection of dark-brown or black bloody fluid, which have given rise to suspicions of poisoning in infants to all outward appearances quite healthy. An infant may be thrown into water and drowned. No traces of this mode of death would be discoverable in the infant unless respiration had taken place prior to its immersion. The plea of accidental drowning in a cesspool or water-closet pan may be put forward ; it is therefore well to examine the cord. Has a ligature been placed upon it ? Has it been cut by a sharp instrument ? The nature and character of the fluid found in the stomach should be noted.

Fractures of the skull may happen—

1. *In the Womb.*—The parturient female may fall from a considerable height, and thus cause injury to her child. These cases are of no judicial importance, as the presence of intra-uterine putrefaction or an examination of the lungs will at once show that the child has not breathed. It must be borne in mind, however, that dislocations may take place in the womb, and this fact may be brought forward in defence. The history of the case, and the absence of any other signs of violence, will decide the truth or falsity of the plea.

2. *During Labour.*—Fracture of the cranial bones during labour generally occurs in difficult and protracted labours, which, from this very cause, seldom become the subject of judicial inquiry. In some cases the defective ossification of the bones of the skull may give rise to fractures, which may lead to dangerous mistakes. This deficiency in the process of ossification is thus described by Casper :—" If the bone in question is held up to the

light, this is seen to shine through the opening, which is closed only by the pericranium. When the periosteal membrane is removed, the deficiency in the ossification is seen in the form of a round or irregularly circular opening, not often more than three lines in diameter, though frequently less; its edges are irregular and serrated: these edges are *never depressed, as is the case in fractures;* and neither they nor the parts in their neighbourhood are ever observed to be ecchymosed." The child in these cases may breathe for a short time, and then die without any apparent cause.

3. *By Falls.*—It is beyond doubt possible for a child to be born so precipitately as to fall on the floor and be severely injured, and that even fatally. In cases of alleged precipitate birth, to account for injuries found on the child, the following points should be remembered, and will assist in forming a diagnosis:—

1. In favour of Precipitate Birth and Accidental Injury.

(*a*) Rupture of the Umbilical Cord. — In all cases it would be advisable to measure the length of the cord, and then the distance of the vulva from the ground, allowing of course for the woman not being quite erect at the time of delivery owing to a separation of the legs. A disproportion between the two measurements may or may not account for the rupture of the cord. The following measurements may be taken:—Usual length of cord, eighteen to twenty inches; distance of vulva from the ground, twenty-six inches, but allowing for stooping, two-thirds of the above. To the length of the cord must be added about nine inches, the distance from the navel to the top of the head of the child. Thus, a fall of about thirty inches will put no strain on the cord. A case is on record of a rupture of the cord taking place while the woman was in a *recumbent* position, but in that case the labour was precipitate, and the cord very short and small.

(*b*) Placenta not detached from the child.

(*c*) Fracture of the parietal bones; the fracture radiating into the frontal and squamous portion of the temporal bone. In experiments on twenty-five children dropped from a height of thirty inches, one parietal bone was found fractured in sixteen of the cases; both parietals, in six cases. The fractures in most cases occurred about the parietal protuberances. It must be remembered that the children were dead, and that it is easier to fracture the skull of a live infant than that of a dead one.

(*d*) Imperfect ossification of the bones of the skull.

(*e*) Absence of other injuries.

2. In favour of Criminal Violence.

(*a*) The fact of the umbilical cord being divided by some sharp instrument and not torn. A caution must be here inserted, for Taylor mentions a case where rupture of the cord occurred in such a manner that it could not be decided whether it had been intentionally cut or torn.

(*b*) Extensive fracture of one or more of the bones of the cranium.

(*c*) Fracture and dislocation of the neck.

(*d*) Presence of incised wounds, and other evidence of violence.

N.B.—In all doubtful cases, a guarded opinion should be given, stating simply that the dissection does not reveal anything contrary to the statements offered as to the cause of death.

III. Congenital Disease in one or more of the Fœtal Organs.—In all cases the presence of congenital disease must be sought for.

IV. Neglect or Exposure, constituting "Infanticide by Omission." — Under this head may be mentioned the following:—

(*a*) Neglecting to place the child in such a position so that it may breathe freely.

(*b*) Neglecting to protect the child from extremes of cold or heat.

(*c*) Neglecting to feed it with the food appropriate to its age. (See Signs of Death from Starvation, page 114.)

(*d*) Neglecting to tie the umbilical cord.

To give answers to these questions will in many cases be impossible, and each must be decided by such circumstances as present themselves in each individual case. For instance, if the body is found stiff, blanched, naked or nearly so, lying on the ground, the vessels of the interior gorged with blood, whilst the superficial vessels are contracted and can be seen only with difficulty; at the same time, the hydrostatic test shows that respiration has taken place, and the absence of all external or internal causes, the probability is in favour of death by cold. In close relation with the present subject is the question—

Has the Infant bled to Death?—Fatal hæmorrhage from the cord may occur, especially if it be divided

by a sharp instrument close to the body of the child. As a rule, hæmorrhage does not occur from a ruptured cord. (The signs of death from hæmorrhage have been noticed, page 81.)

How long did the Child survive its Birth?—The answer to this question is by no means easy, and the data on which a decision can be based are not very reliable. The presence or absence of the *vernix caseosa* should be noticed. In still-born children the closed eyelids, when raised, do not remain open; in the live-born, on the other hand, the eyes remain half open even after repeated attempts to close them. Another guide to the determination of the length of time the child survived its birth may be found in the absence or presence of the meconium in the intestines. The meconium—from its resemblance to inspissated poppy juice—is found in the large intestine as a dark-greenish pasty mass, more or less filling that portion of the bowel. In the upper portions of the intestines it varies from a light-yellowish or greyish to a greenish brown colour, till in the large intestine it assumes the colour and consistence above-mentioned. It is generally discharged by the infant in from four or five to forty-eight hours after birth. In breech presentations it may be passed during the process of delivery, although the child be still-born; but its entire absence from the intestines is presumptive of existence for some days after birth.

The following are some of the points to be considered in forming a diagnosis:—(1) Changes in the skin. (2) Changes in the umbilical cord. (3) Changes in the circulatory system.

1. *Changes in the Skin*—Exfoliation of the cuticle. The time at which this occurs is so variable as to be of little value in a medico-legal inquiry.

2. *Changes in the Umbilical Cord.*—Mummification of the cord is not of the slightest value as a proof of extra-uterine life ; but the separation of the cord which occurs between the fourth and seventh day, especially when cicatrisation has taken place, is a sure sign that the child must have lived four or five days at least. Two other appearances of some value may also be noted, namely :—

(*a*) In fresh bodies, the appearance of a bright-red ring about a line in breadth, which surrounds the insertion of the cord, and which is formed within the uterus.

(*b*) A similar red ring, about two lines broad, around the insertion of the cord, accompanied with "*thickening, inflammatory swelling of the portion of the skin affected, and slight purulent secretion from the umbilical ring itself.*" This latter condition Casper considers as affording "*irrefragable proof of the extra-uterine life of the child.*

3. *Changes in the Circulatory System.*

(*a*) Ductus Arteriosus. — Arterial duct. A contracted condition of this duct is of no value as a proof that a child has survived its birth; for the duct is liable to become contracted, and even obliterated, before the birth of the child.

(*b*) Ductus Venosus.—Nothing certain is known as to the exact time when this duct closes; the condition of the vessel is, therefore, of no assistance in determining the possibility of the child having survived its birth. The duct has been found closed in a still-born child; and in one child, which lived for a quarter of an hour, both the *ductus arteriosus* and the *foramen ovale* were found closed. Cases are also on record in which the fœtal channels were found open after thirty days of extra-uterine life.

(*c*) Foramen Ovale.—What has been said of the preceding may be said with regard to the foramen ovale.

N.B.—To sum up, therefore, in the fewest words, any attempt at forming an opinion on the *docimasia circulationis* may result in a fatal error on the part of the medical witness, as it is impossible to determine with any accuracy by days the period of their closure. As a general statement, however, the following, according to Bernt and Orfila, is the order in which obliteration of the fœtal vessels takes place :—(1) The umbilical arteries. (2) Ductus venosus. (3) Ductus arteriosus. (4) Foramen ovale.

TABLE SHOWING HOW LONG A NEW-BORN CHILD HAS LIVED.

	At Birth, but before Respiration.	From 1 to 24 Hours.	From 2 to 3 Days.	From 3 to 4 Days.	From 4 to 6 Days.	From 6 to 12 Days.
Skin.	As a rule, very red, soft, smooth, and covered with a whitish, fatty, sticky coat (*vernix caseosa*).	The skin is firmer and rosy, and the vernix caseosa not so white.	The skin assumes a yellowish tint. Sometimes on the abdomen and base of the chest, the epidermis shows signs of approaching exfoliation.	The icteric colour of the skin is more marked. Exfoliation of the skin has begun over belly and base of the chest.	The exfoliation of the skin extends from the groins to the axillæ, and between the shoulders. the epidermis is detached in strips, in scales, or as a firm powder.	The exfoliation of the skin has extended to the extremities.
Head.	Presence of caput succedaneum.	....	The caput succedaneum has disappeared, leaving only a slight ecchymosis.	....	....	....
Umbilical Cord.	Is fresh, firm, bluish, roundish, more or less spongy. The ductus arteriosus is four to six lines long. Its diameter is double	The umbilical cord is withering, and the calibre of the arteries are beginning to diminish from the thickening of their walls.	The cord is brown from its extremity to its base, is less moist, and already shows signs of mummification. The vessels are not easily	The cord is of a brownish-red colour, flattened and distorted. The vessels are twisted like a gimlet. The arteries are in great	The cord is detached from the abdomen, the membranes first, then the arteries, and last, the vein. The arteries and the vein are quite	If the cord was thin, cicatrisation is complete before the tenth day. The arteries, the vein, and other fœtal canals are obliterated. If

TABLE SHOWING HOW LONG A NEW-BORN CHILD HAS LIVED—*Continued.*

	At Birth, but before Respiration.	From 1 to 24 Hours.	From 2 to 3 Days.	From 3 to 4 Days.	From 4 to 6 Days.	From 6 to 12 Days.
	that of each of the branches of the pulmonary artery.		made out, being flattened, and contain a fine clot more or less contracted.	part obliterated, the calibre of the vein and ductus venosus is diminished, but they and the foramen ovale are still open. The circumference of the ring is injected and begins to show signs of inflammation, with the discharge of a sero-purulent fluid at the base of the cord.	obliterated. The ductus arteriosus and foramen ovale diminished in size are still open.	the cord was thick, a sero-purulent discharge may continue to the twenty-fifth or thirtieth day.
The Large Intestine.	The large intestine contains meconium.	The meconium is discharged, but the large intestine still contains thick greenish mucus.	The green mucus which covered the intestine is detached in places.	The green mucus almost absent.	The green mucus quite absent.	....

SYNOPSIS.

1. Infanticide is not regarded as a specific crime.

2. To be tried by the same rules of evidence as apply to murder.

3. The law presumes that every child is born dead, till proof to the contrary is given.

4. Onus of proving live-birth devolves on the prosecution.

5. The body need not be found in order to obtain conviction of the suspected party, if not of infanticide, at least of concealment of birth.

The medical evidence, however, depends on the body being found and examined.

The medical witness may be examined on one or more of the following points :—

(1) The recent delivery of the accused.

(For "Signs of Recent Delivery," see page 141.)

(2) Maturity of the child found?

(3) Was the child still-born or live-born?

(4) Cause of death.

(5) Lastly, as to the mental condition of the mother. Puerperal mania, etc.

6. In absence of proof of infanticide, the woman, in England, may be tried for *concealment of birth*, that is, disposing secretly of the body, whether the child be born dead or alive.

7. In Scotland, a woman may be tried for *concealment of pregnancy* when the child is dead or missing, if she do not call for or make use of help or assistance in the birth; but the case is quashed, if the child be shown alive by the mother to others.

INHERITANCE.

This subject will be discussed under the following heads :—(1) The child must be born alive. (2) The child must be born during the lifetime of the mother. (3) The child must be born capable of inheriting. (4) Tenancy by courtesy, and *possessio patris.*

1. The Child must be born alive.—This has been discussed in the preceding section.

2. The Child must be born during the lifetime of the mother.—Death terminates the marriage contract. Would a child born after the death of the mother, and therefore not during marriage, be entitled to inherit?

On this point Lord Coke writes :—"If a woman, seised of lands in fee, taketh husband, and by him is bigge with childe, and in her travell dyeth, and the childe is ripped out of her body alive, yet shall he not be tenant by the curtesie, because the child was not born during the marriage nor in the life of the wife; but in the meantime her land descended."

It appears from this that the husband is not entitled to the life-rent.

3. The Child must be born capable of inheriting.—Monsters cannot inherit according to law. Blackstone says :—"A monster which hath not the shape of mankind hath no inheritable blood," and cannot, therefore, inherit; but, "if it hath human shape, it may be an heir."

Buffon classes monsters under three divisions :—(*a*) Monsters by excess of organs. (*b*) Monsters by defect of organs. (*c*) Monsters by alteration or wrong position of parts.

A hermaphrodite inherits, or not, property according to the prevailing sex.

4. **Tenancy by Courtesy and *Possessio Patris*.**—"When a man marries a woman seised of an estate of inheritance, and has by her issue *born alive*, which was capable of inheriting her estate; in this case he shall, on the death of his wife, hold the lands for his life as tenant by the courtesy of England."

There is yet another case bearing closely on this subject, known in law as *possessio patris*. On this subject Mr Amos writes:—"In the event of a man twice married dying, and leaving a daughter by each marriage, his estate would be equally shared by the daughters of the two marriages; but if we suppose that there is also a son by the second marriage, born in a doubtful state, the legal effect of his momentarily surviving birth would be to disinherit the daughter of the first marriage entirely, and transfer the whole of the estate to the daughter of the second marriage, she being sister to the male heir, while the daughter of the first marriage is only half-blood."

In both of these cases proof of live-birth, as before mentioned, is of the slenderest kind.

A fœtus in the womb (*en ventre sa mère*) may—(*a*) Have a legacy or estate made over to it. (*b*) A guardian assigned to it.—That these conditions may take effect, it must be born alive. (*c*) Be an executor.—To exercise this *post partum* function, the child must in England, have attained the age of twenty-one.

LEGITIMACY.

Every child born in wedlock is presumed to have the husband of the woman as its father; but this presumption may be denied for the following reasons:—

1. Absence or death of the reputed father.

2. Impotence or disease in the reputed father, preventing matrimonial intercourse.

3. In the case of a premature delivery in a newly-married woman.

4. Want of access.

5. The paternity of the child may be disputed when the woman marries immediately after the death of her husband.

In Scotland, a child is held to be legitimate if born ten lunar months after the death or absence of its alleged father; and the absence of the supposed father must continue till within six lunar months of the birth of the child, to prove its illegitimacy.

In the same country, a child born before marriage is rendered legitimate by the subsequent marriage of the parents. This is not the case in England.

A child born during wedlock is legitimate, although the date of conception may be before marriage. A child born after the death of its mother is held to be legitimate. A child may, as Taylor remarks, be conceived before marriage, and born after the death of the mother, and yet be legitimate, though neither conceived nor born in wedlock.

The code Napoleon prohibited the contraction of a second marriage until ten months after the death of the first husband; and this is also the case in Germany. The Anglo-Saxon law prohibited re-marriage for twelve months. In Britain no time is fixed by law.

Duration of Pregnancy.—The consideration of this subject is of importance in its relation to the legitimacy of a child.

The natural period of human gestation is usually stated at forty weeks, ten lunar or nine calendar months, or 280 days. In Prussia, the period is extended to 302 days, and in the code Napoleon to 300; in Scotland, ten months is held as the limit.

The duration of human gestation is subject to considerable variation; in some females it is always protracted; in others, always premature. Several modes of calculation are adopted by women:—

1. Ascertained date of impregnation from one coitus.

2. Supposed sensations of female at time of conception.

3. Suppression of the catamenia.—This is open to the objection, that causes other than that of impregnation may arrest them. The catamenia may be stopped by cold or other causes for two or three months, and then, before their return, pregnancy may occur, thus upsetting all calculations. The usual mode of calculation is from two weeks after the last menstruation, and the period so fixed is corrected by the time at which quickening occurs.

4. Period of quickening. — (*a*) Quickening supposed when pregnancy is absent. (*b*) Pregnancy without quickening. (*c*) Variations in the time of its occurrence.

Whichever may be the mode of calculation adopted, it may be stated that, as a rule, the period of human gestation is from 275 to 280 days, and that cases of alleged pregnancy beyond 300 days must be received with considerable caution.

The pregnancy of the Countess of Gloucester was held, in the reign Edward II., to be legitimate, although her husband had been dead one year and seven months at the date of the application.

Premature Births.—The question may be asked, At what period of gestation may a child be born viable —that is, capable of living and attaining to maturity? Seven months, or 210 days is considered as the limit; but cases have been recorded of children born at six months being reared. The Roman law admitted the legitimacy of seven-months' children. (For the Signs of Immaturity, see "Table of the Development of the Embryo," page 169, *et seq.*)

Superfœtation.—This term is used to imply the conception of a second embryo in a woman already pregnant, and the birth of two children at one time,

differing considerably in their maturity, or of two births, a considerable period of time elapsing between each. The possibility of this occurrence has been doubted.

Churchill, in his work on Midwifery, writing on this subject says:—"In conclusion, I would say—(1) That the theory of superfœtation is *unnecessary* to explain the birth of a mature fœtus and a blighted ovum, of a mature and immature fœtus born together or within a month of each other, or of fœtuses of different colours, as they may reasonably be supposed to be the product of one act of generation, or of two nearly contemporaneous. (2) That, in cases of double uterus, it is possible for a second conception to take place, and—judging from the subsequent birth of the second child in the only case on record—at a later period than the first. (3) That, in the remaining cases, where one mature child succeeded the birth of another after a considerable interval, we have no proof of a double uterus in any, and positive proof that in one case it was single; and that to the explanation of these cases no theory as yet advanced is adequate, that of superfœtation being opposed by physical difficulties which are insurmountable in the present state of our knowledge."

The late Dr Matthews Duncan has, however, shown that the mouth of the womb is not immediately closed by conception, and that the communication between the vagina and ovary is not destroyed for some months after impregnation, and that there is no impediment to the ascent of the spermatozoa.

The late Dr Milne, while admitting this form of pregnancy as possible, though very rare, remarks:—"This variety we should not think due so much to mechanical hindrances as to the absence of proper ovules. It would imply extraordinary vigour were perfect ovulation to be achieved for any length of time after impregnation."

IMPOTENCE AND STERILITY.

IMPOTENCE.

Impotence in the male may arise from—(1) Functional causes. (2) Organic causes.

1. **Functional.**—Excessive use of alcoholic stimulants, excessive venery, masturbation, and certain debilitating diseases.

2. **Organic.**—Malformation of the genital organs, deficiency of the penis, fistula in perineo, or malformation of the urethra—*hypospadias*—especially when the opening of the urethra is at a considerable distance from the glans. Absence of the testicles from the scrotum does not necessarily imply incapacity for procreation, for persons *(crypsorchides)* in whom the testicles are retained in the abdomen have been capable of begetting children. Cancer of the testicle, or the presence of any other organic disorganisation of the gland, may be considered as a bar to procreation; but even removal of the testicles after puberty does not destroy the power of procreation for a short time after their removal, and men have been known to enjoy the power of copulation for ten years after the operation of castration (Sir A. Cooper). Sterility may be present without impotency.

STERILITY.

Sterility in the female may arise from—(1) Organic causes. (2) Functional causes.

1. **Organic.** — Absence of the ovaries, uterus, or vagina, imperforate hymen, tumours in the vagina, etc. Dr Ogston, in referring to this subject, states:—" If I may judge from what I have since met with in the dead-house, these last affections (fibroid of the uterus) and also obstructions of the fallopian tubes,

seem to be usual in prostitutes, and may account in these instances, independently of other alleged causes, for their frequent sterility."

2. **Functional.**—Extreme debility—though this is not always an impediment, for some weak debilitated women conceive rapidly. Constant leucorrhœa may be a cause of sterility; so also may dysmenorrhœa, menorrhagia, and amenorrhœa. Some years ago, I successfully treated a lady for profuse leucorrhœa, who had not borne a child for nine years; she then bore two children in rapid succession. After the birth of the last, seven years ago, the leucorrhœa returned, which she prefers to the possibility of another pregnancy. It must also be borne in mind that women may be sterile with one man and fertile with another, as in the case of two men who, travelling together with their wives to drink the waters of a celebrated spring on the Continent, accidentally and unconsciously changed wives at an inn, when both wives became pregnant. I have met with the case of a lady who was married for ten years without issue, but who, on contracting a second marriage, bore children rapidly.

To sustain an application for divorce on the ground of impotence, the cause or causes must have existed before marriage. In one case, a nullity of marriage was granted because every attempt at sexual intercourse brought on an attack of hysteria in the wife (H. *v.* P., 3 P. and M., 126).

A medical man may be required to ascertain the capability or incapability of a man for sexual intercourse in—(1) Cases of contested legitimacy. (2) Suits for divorce. (3) Accusations of rape.

Unless there be absolute deformity, or other positive physical cause, no medical man is justified in asserting that impotence or sterility exists.

SURVIVORSHIP.

The question of survivorship is not infrequently raised when a mother and her new-born infant are found dead, or where several persons have perished by a common accident. In the first case, the mother is generally presumed to have lived longest; and this presumption may be borne out by the fact of the delivery being premature, or if there be considerable disproportion between the size of the child and the maternal passages. As pointed out before, important civil rights may depend upon the question as to the live-birth of an infant; and the husband's rights to be *tenant to the courtesy* will, of course, depend upon the view taken as to the probable survivorship or not of the child.

With regard to the second question, much will depend upon the relative ages and strength of the individuals. Sex will also have to be taken into consideration. In the case of one or more persons found dead, either from wounds or other causes, the fact of some being warm and others cold, the presence of the *rigor mortis* in one and absence in the other, will point to the probable survivorship. The severity of the wounds and injuries to large arterial trunks must also be considered. (See test case, Underwood *v.* Wing, 1 Jur. N.S., 169.) In this case a man, his wife, and three children were washed overboard and drowned, one child, however, being seen alive a few minutes after the others were submerged. The question at issue was, Did the husband survive the wife, or the wife the husband? and on this Wightman, J., in summing up said:—"We may guess, or imagine, or fancy, but the law of England requires evidence, and we are of opinion that there is no evidence upon which we can give a judicial opinion that either survived the other; in fact, we think it unlikely that both did die at the same moment of time, but there is no evidence to show who was the survivor." Verdict for the plaintiff.

MALPRAXIS AND NEGLECT OF DUTY.

A medical man is liable to a civil action for damages, who, by a culpable want of care and attention, or by the absence of a competent degree of skill and knowledge, causes injury to a patient. And it is not necessary that the patient should have employed or was to have paid him, provided always that there be no negligence or carelessness on the part of the patient. Lord Chief-Justice Tindall remarks :—"Every person who enters into a learned profession undertakes, to bring to the exercise of it a reasonably fair and competent degree of skill." It has also been decided that if the defendant acted honestly, and used his best skill to cure, and it does not appear that he thrust himself in the place of a competent person, it makes no difference whether he was at the time a regular physician or surgeon or not. (R. *v.* Van Butchell; R. *v.* Williamson, etc.) A surgeon does not undertake to perform a cure, nor does he profess to bring the highest professional skill into the consideration of the case ; but he does undertake to bring a fair and reasonable amount. The degree of skill required by law is good common sense, or such knowledge as the operator had, joined with a good purpose to help the afflicted, even if such interference rendered the patient a cripple for life. "It would be dreadful," says Hullock, B., "if every time an operation was performed an individual was liable to have his practice questioned." "So, if a physician or surgeon give his patient a potion or plaster to cure him, which, contrary to expectation, kills him, this also is neither murder nor manslaughter, but misadventure." A medical man is only liable for gross negligence, not for every slip he may make ; but the distinction between criminal and actionable negligence cannot be defined; but it appears that the negligence must be so gross as to come under the legal meaning of the word "felonious."

FEIGNED DISEASES.

Human ingenuity is not wanting among those who, for private ends, pretend to be suffering from disease. The soldier or sailor, anxious to escape the dangers of active service, finds a ready means of evading his duties by shamming; the prisoner, in order to lighten the burden of his punishment, does the same. A man declares himself impotent, to save the expense of keeping an alleged bastard child, or to avoid punishment for rape. Beggars appeal to the public by feigning some painful disease, and incautious benevolence becomes the dupe of the clever impostor.

Any attempt at classification is here out of the question, nor does it appear necessary to give a long list of diseases which have been feigned, or the means that have been employed by artists in deception. To give some general hints for guidance is all that will be attempted here, leaving matters of detail to the acumen of the medical examiner, who, if in active practice, will have many opportunities of testing his powers of discernment:—

1. Never be satisfied with one visit, but pay a second at a short interval, and unannounced.
2. Have the patient carefully watched in the interval of your visits.
3. Examine each organ of the body separately, carefully comparing the state of each with the symptoms described by the patient.
4. Note the discrepancies in the statements of the patient as to his symptoms, and their known occurrence in real disease.
5. Sometimes ask questions the reverse of his statements, or take his statements for granted, when in all probability he will contradict himself.
6. Remove all bandages and other dressings.
7. The administration of sham physic, or the suggestion of some heroic mode of treatment; the application of the actual cautery may have a beneficial effect.
8. Pay little attention to the reports of bystanders, or of the culprit's fellow-prisoners.
9. Anæsthetics may be employed, if necessary, for the purpose of detection.
10. The motives for deception should be inquired into, and borne in mind, in the examination of all cases.

EXEMPTION FROM PUBLIC DUTIES.

The existence of certain diseases may be claimed as a bar to active service, both in a civil and in a military capacity; and the opinion of a medical man may be required as to the fitness or unfitness of the individual for the service from which he claims exemption. In giving certificates of this nature, the medical practitioner cannot be too guarded in wording them; and each case must be treated on its merits, so that strict justice may be done.

Among the diseases which may incapacitate a man for active employment may be mentioned—Syphilis; hernia; phthisis; affections of the eyes, attended with dimness of vision, or colour blindness; varicose veins; and some other diseases. For the army, a man is not considered fit for active service until he is twenty-one years of age.*

WILLS.

Although a medical man, as a rule, should refuse to draw up a will, still there are occasions when his doing so may save much litigation and expense. The following directions may therefore be of use:—

1. Let the wishes of the testator be expressed in the plainest and simplest words, avoiding all expressions that seem to admit of another meaning than the one intended.
2. All alterations in the will should be initialed.
3. Do not scratch out a word with a knife, and no alteration must be made after the will is *executed.*
4. Two witnesses are necessary, who must both be present and sign the following attestation at the end of the will, or on each sheet if more than one sheet of paper be used:—" Signed by the testator (or testatrix as the case may be) in the joint presence of us, who thereupon signed our names in his (or her) and each other's presence."
5. Add address of witnesses.
6. A clause appointing an executor should be inserted thus:— " And I appoint J. B. executor of this my will."
7. Begin " This is the last will of me, W. B. of S."; and end " and I revoke all former wills and codicils." Dated this day of one thousand, etc.

* See Aitken's "Growth of the Recruit and Young Soldier."

MENTAL UNSOUNDNESS.

In the whole range of medical jurisprudence there is no subject more interesting, more difficult, or more important than the diagnosis of insanity, and its relation to the criminal responsibility of individuals. It is impossible, in the short space at our disposal, to do more than to offer a few remarks which may assist the student in the elucidation of some of the most important cases which may engage his attention.

Legal Definitions.—Three forms of mental disorder are recognised in law :—

1. *A nativitate, vel dementia naturalis*—idiocy or natural fatuity.

2. *Dementia accidentalis, vel adventitia*—general insanity, either temporary or permanent, lunacy.

3. *Dementia affectata,* acquired madness from intoxication, etc. (See "Delirium Tremens," page 211.)

Under the term lunacy are included the mania, monomania, and dementia of medical writers. Another term frequently used in legal proceedings, the meaning of which it is not easy to give, is "*non compos mentis,*" *unsoundness of mind.* According to the late Forbes Winslow, "unsoundness of mind is not lunacy" in the legal acceptance of the phrase. This term was first used in a Statute passed in the reign of Henry VIII., relating to the punishment of treasonable offences; and is defined by the early law text-books to be strictly one who *gaudet lucidis intervallis*—a definition not psychologically exact. The phrase "unsoundness of mind" was first used by the late Lord Eldon to designate a state of mind not exactly idiotic, and not lunatic with delusions, but a condition of intellect occupying a place between the two extremes, and unfitting the person for the government of himself and the management of his affairs.

The above definition has been acted upon by other Judges—Lyndhurst, Brougham, etc. As a rule, a

medical witness will consult his own interest in not attempting to define insanity, bearing in mind the philosophic caution of Polonius, who, when addressing Hamlet's mother, says—

> "Your noble son is mad.
> Mad call I it; for, to define true madness,
> What is't but to be nothing else than mad?"

To the legal mind, the chief character of insanity is the presence of *delusion*; but this view is far too restricted. It was first advanced by Erskine in the trial of Hadfield. Before that trial the doctrine was that every man was responsible for his acts, unless he was totally deprived of his understanding and memory, and did not know what he was doing, "no more than an infant, than a brute, or a wild beast" (R. *v.* Arnold). In the case of Bellingham, the knowledge of "right" and "wrong" in the abstract was the test of mental unsoundness; and, as in the opinion of the Judge and Jury, he was held to be capable of solving this metaphysical problem, Bellingham was duly hanged.

Since the trial and acquittal of MacNaughton on the ground of insanity, the doctrine of the knowledge of abstract right and wrong has been changed to a knowledge of right and wrong in relation to the particular act of which the person is accused, and also at the time of committing it.

It has also been held that, on the assumption that a person labours under partial delusion only, and is not in other respects insane, he must be considered in the same situation as to responsibility as if the facts, with respect to which the delusion exists, were real. For example, if under the influence of delusion, he supposes another man to be in the act of attempting to take his life, and he kills that man, as he supposes in self-defence, he would be exempt from punishment. If his delusion was that the deceased had inflicted a serious injury on his character and fortune, and he killed him in revenge for such supposed injury, he would

be liable to punishment. "Here," says Maudsley, "is an unhesitating assumption that a man, having an insane delusion, has the power to think and act in regard to it *reasonably*, . . . that he is, in fact, bound to be reasonable in his unreason, sane in his insanity." Yet this was the doctrine laid down by the Judges in answer to certain questions propounded by the House of Lords after the acquittal of MacNaughton. (See Maudsley's "Responsibility in Mental Disease," page 88, *et seq.*)

As laid down by English lawyers, madness absolves from all guilt in criminal cases. Where the deprivation of the understanding and memory is total, fixed, and permanent, it excuses all acts; so, likewise, a man labouring under adventitious insanity is, during the frenzy, entitled to the same indulgence, in the same degree, with one whose disorder is fixed and permanent (Beverley's Case, Co. 125, Co. Litt. 247, 1 Hale 31). "But the difficulty in these cases is to distinguish between a total aberration of intellect and a partial or temporary delusion merely, notwithstanding which the patient may be capable of discerning right from wrong; in which case he will be guilty in the eye of the law, and amenable to punishment." *

Lord Hale, who first pointed out the distinction to be drawn between total and partial insanity, offered the following as the best test he could suggest:—"Such a person, as labouring under melancholy distempers, hath yet as great understanding as ordinarily a child of fourteen years hath, is such a person as can be guilty of felony." (On this subject, see R. *v.* Ld. Ferrers, 19 St. Tr. 333; R. *v.* Arnold, 16 St. Tr. 764, etc.)

To excuse a man from punishment on the ground of insanity, it appears that it must be distinctly proved that he was not capable of distinguishing right from wrong, and that he did not know, at the time of committing the

* Archbold's "Criminal Cases."

crime, that the offence was against the laws of *God* and *nature* (R. *v.* Offord, 5 C. and P. 186).

I shall here quote from Macdonald's "Criminal Law of Scotland":—"Insanity or idiocy exempts from prosecution. But there must be an alienation of reason such as misleads the judgment, so that the person does not know "the nature of the quality of the act" he is doing, or if he does know it, that he does not know he is doing what is wrong. If there be this alienation, as connected with the act committed, he is not liable to punishment, though his conduct may be otherwise rational. For example, if he kill another when under an insane delusion as to the conduct and character of the person—*e.g.*, believing that he is about to murder him, or is an evil spirit,—then it matters not that he has a general notion of right and wrong. For, in such a case, "as well might he be utterly ignorant of the quality of murder." He does the deed, knowing murder to be wrong, but his delusion makes him believe he is acting in self-defence, or against a spirit. Nor does it alter the effect of the fact of insanity at the time, that the person afterwards recovers. . . . . But the alienation of reason must be substantial. Oddness or eccentricity, however marked, or even weakness of mind, will not avail as a defence. Even monomania may be insufficient as a defence, where the delusion and the crime committed have no connection, or where the person, though having delusions, was yet aware that what he did was illegal."

Mere moral insanity—where the intellectual faculties are sound, and the person knows what he is doing, and that he is doing wrong, but has no control over himself, and acts under an uncontrollable impulse—does not render him irresponsible (R. *v.* Burton, 3 F. and F. 772). Some medical writers contend that there are two forms of insanity—moral and intellectual. The law only recognises the latter, owing probably to the difficulty of distinguishing between so-called moral

insanity and moral depravity. Taylor says:—"Further, until medical men can produce a clear and well-defined distinction between moral depravity and moral insanity, such a doctrine, employed as it has been for the exculpation of persons charged with crime, should be rejected as inadmissible."

The day may not be far distant when the term "moral depravity" will be unknown, and future generations, ceasing to believe in absurd superstitions, will come to look on crime as the result of disease of the brain, and learn to treat, instead of to punish, the morally diseased. (For a full discussion of this subject, the reader is referred to the works of Dr Henry Maudsley.)

The fact of the sanity or insanity of the prisoner at the time the crime was committed is left to the Jury to decide, guided by the previous and contemporaneous acts of the party; and it has been laid down by Lord Moncreiff in Scotland, and Lord Westbury in England, that the mental soundness or unsoundness of any individual is to be decided by the Jury on the ordinary rules of every-day life, and that on these principles they are as good judges as medical men. The whole tendency of legal practice, when dealing with the plea of insanity, is to entirely ignore the medical evidence. On the question of medical evidence in cases of insanity, Doe. J., of New Hampshire, remarks—"At present, precedents require the Jury to be instructed by experts in new medical theories, and by Judges in old medical theories," and that in this "the legal profession were invading the province of medicine, and attempting to instal old exploded medical theories in the place of facts established in the progress of scientific knowledge. If the tests of insanity are matters of law, the practice of allowing experts to testify what they are should be discontinued; if they are matters of fact, the Judge should no longer testify without being sworn as a witness, and showing himself qualified to testify as an expert."

Lunacy—what Constitutes? (8 and 9 Vict. c. 100, secs. 90 and 114.)—Imbecility and loss of mental power, whether arising from natural decay; or from paralysis, softening of the brain, or other natural cause, and although unaccompanied with frenzy or delusion of any kind, constitute unsoundness of mind, amounting to lunacy within the meaning of 8 and 9 Vict., c. 100. (R. *v*. Shaw, 1 C.C. 145.)

The above is the last definition of lunacy up to 1875; but as the law on this subject is so constantly changing, the student will find it best to consult the "Law Reports" from time to time. (See the account of the case of R. *v*. Treadaway, "Law Reports." Also the "Lancet," on the same case, vol. i., 1877.)

For some valuable remarks on the subject of the irresponsibility of madmen, the student is referred to the works of Maudsley, Prichard, Ray, Hoffbauer, Georget, and others.

The following suggestions are offered for consideration on this subject:—

1. Was the act an isolated event in the life of the culprit? Has it the appearance of spontaneity, or was it the culminating point of a life spent in so-called criminal acts?

2. Absence of a motive for the committal of the deed.—The absence of an *apparent* motive is no proof of an unsound mind; the moving principle may be "*the conscious impulse to the illegal gratification of a selfish desire*."

3. The presence or absence of a well-concerted plan of action is a diagnostic sign of little value.—Casper remarks that "only in one case can the examination of the systematic planning of the deed afford any information, and that is when these plans and preparations themselves evince the stamp of a confused intellect, and betray the hazy consciousness, the mental darkness, in which the culprit was involved."

4. A dominant delusion may be so concealed as to be for a time undiscoverable.—The case of the man who gave no indication of his madness till he was asked to sign the order for his release, when he signed *Christ*, is an example how carefully a delusion may be concealed even during a most careful examination. Questions directed to this point showed that he laboured under all the errors which such a delusion might suggest.

5. It may "easily be conceived that insane persons, whose unreason affects only one train of thought more or less restricted, yet labour in other respects under disorders of feeling which influence their conduct and their actions and behaviour, without materially affecting their judgment: and that many of such deranged persons, who often conduct themselves tolerably well in a lunatic asylum, and while living among strangers with whom they have no relations, and against whom they have no prejudices or imaginary reason of complaint; subjected, besides, to the rules of the house and to an authority that nobody attempts to dispute; would, nevertheless, if restored to liberty and residing in the midst of their families, become insupportable, irritable at the slightest contradiction, abusive, impatient of the least remark on their conduct, and liable to be provoked by trifles to the most dangerous acts of violence. If, under such circumstances, a lunatic should commit any act of injury or serious damage to another, would it be just to punish him; because it cannot be made apparent that the action has any reference to, or connection with, the principal illusion which is known to cloud his judgment; it being apparent that his moral faculties have undergone a total morbid perversion?"

6. Insanity with lucid intervals.—Haslam, Ray, and others appear to deny the possibility of lucid intervals; but M. Esquirol, on the other hand, fully recognises the existence of this form of insanity. In a legal sense, a temporary cessation of the insanity constitutes a lucid

interval, but the cessation must be complete, and not merely a remission of the symptoms. The interval must be of some duration; and when continuous insanity has been proved, the onus of proving a lucid interval in civil cases rests with the party trying to support the validity of a deed executed during the alleged interval. "If you can establish," says Sir W. Wynne, "that the party afflicted habitually by a malady of the mind has intermissions, and if there was an intermission of the disorder at the time of the act, that being proved is sufficient, and the general habitual insanity will not affect it, but the effect of it is this—it inverts the order of proof and presumption; for, until proof of habitual insanity, the presumption is that the party agent, like all human creatures, was rational; but when an habitual insanity in the mind of the person who does the act is established, then the party who would take advantage of the fact of an interval of reason must prove it." In civil cases the law recognises the validity of wills made during lucid intervals, and has even taken the reasonableness of a will as a proof of a lucid interval.

7. Have measures been taken by the culprit to escape punishment?

The classification adopted here is that given by Ray, and is sufficient for all practical purposes :—

INSANITY.	Defective development of the faculties.	*Idiocy*	1. Resulting from congenital defect.
			2. Resulting from an obstacle to the development of the faculties supervening in infancy.
		Imbecility	1. Resulting from congenital defect.
			2. Resulting from an obstacle to the development of the faculties supervening in infancy.
	Lesion of the faculties subsequent to their development	*Mania*	1. Intellectual— (*a*) General. (*b*) Partial.
			2. Affective— (*a*) General. (*b*) Partial.
		Dementia	1. Consecutive to mania, or injuries of the brain.
			2. Senile, peculiar to old age.

DEFECTIVE DEVELOPMENT OF THE FACULTIES.

IDIOCY. CRETINISM. IMBECILITY.

Idiocy is congenital, and was defined by Esquirol thus :—Idiocy is not a disease, but a condition in which the intellectual faculties are never manifested, or have never been developed sufficiently to enable the idiot to acquire such an amount of knowledge as persons of his own age, and placed in similar circumstances with himself, are capable of receiving. Idiocy commences with life, or at an age which precedes the development of the intellectual and affective faculties, which are from the first what they are doomed to be during the whole period of existence. Since the days of Esquirol, much improvement has been made in the care and treatment of the idiot; and it appears that he is capable of some, though in most cases slight, mental culture. The cases in which improvement takes place probably belong to imbecility, leaving the *idiot* in the same condition as described by Esquirol.

Cretinism differs from idiocy in being endemic; it is also more curable, or at least more susceptible of improvement, than the latter. In the idiot the malady is congenital; the cretin, on the other hand, may to all appearances be free from disease for a time. "Every cretin is an idiot, but every idiot is not a cretin; idiocy is the more comprehensive term, cretinism is a special kind of it." The enlarged thyroid gland, high-arched palate, and brown or yellow colour of the skin, are characteristic of the cretin. Local causes seem to be at work in the production of cretinism; but what the exact nature of these causes is has not been definitely settled. It has been attributed to miasma, to overcrowding in low-lying, badly-ventilated houses, and to ill-assorted marriages. Smallness of the brain, premature ossification of the cranium, and want of symmetry

in the brain, have also been mentioned among the causes of cretinism.

The idiot is usually cunning, mischievous, and dirty in his habits.

The derivation of the word idiot, from the Greek, ἰδιώτης—*a private person*, or *an ill-informed ordinary fellow*—is peculiar. A person suffering from any form of mental unsoundness, and thereby rendered incapable of taking care of himself or of his property, was formerly called by English Law "an idiot," and this word was not infrequently joined with "fatuus" in old writs.

Imbecility.—This is a minor form of idiocy, and may or may not be congenital; it also admits of considerable degrees of intensity. Hoffbauer has divided imbecility *(Blödsinn)* into five degrees, and stupidity *(Dummheit)* into three.

Legal Relations of Idiocy and Imbecility.—The legal definition of an idiot is "one who is of non-sane memory from his birth by a perpetual infirmity, without lucid moments." With regard to responsibility or irresponsibility of idiots and imbeciles, much will depend upon the degree of mental weakness present.

MANIA.

Mania is the result of a morbid condition of the brain, and to express which "the term raving madness may be used with propriety, as an English synonym for mania. All maniacs display this symptom occasionally, if not constantly, and in greater or less degrees." Like other diseases, mania observes the same pathological laws. There is a period of incubation, during which the true state of the patient is in most cases misunderstood, or not appreciated. Mental exaltation may exist from the first onset of the disease, or the attack may be ushered in by a stage of gloom or despondency.

The general health shows signs of impairment, the liver becoming sluggish, and the bowels confined or relaxed. In some cases a febrile condition of the system is among the premonitory symptoms of an attack of mania. The physical health is not usually much affected during the paroxysm.

Dr Conolly remarks that "even acute mania is not always accompanied by the ordinary external signs of excitement. It would seem as if we had yet to learn the real symptoms of cerebral irritation. Certainly, in recent cases of mania—cases which have lasted more than six weeks, and in young persons in whom I have seen the maniacal attack pass into dementia—I have known the most acute paroxysms of mania exist, rapid and violent talking, continual motion, inability to recognise surrounding persons and objects, a disposition to tear and destroy clothes and bedding, without any heat of the scalp or of the surface, without either flushing or paleness of the face, with a clean and natural appearance of the tongue, and a pulse no more than eighty or eighty-five."

This may occur in some cases, but in the majority there is always some amount of physical derangement; the system, however, gradually becoming tolerant of the undue excitement to which it is subjected.

Following the classification adopted, Intellectual Mania will now be briefly considered under its two divisions—*General* and *Partial.*

General Intellectual Mania.—By many medical writers general intellectual mania is divided into mania and melancholia. The mind in the former form of the disease is involved in the most chaotic confusion possible, and there is also considerable bodily derangement. The moral faculties become more or less affected, and the patient's social and domestic relations are greatly altered. At one time

he is subject to violent fits of immoderate laughter, at another he is gloomy and taciturn; sometimes quiet and tractable, at others wild and excited, necessitating close confinement. He is haunted by wild delusions, which at times take entire possession of him, and under the influence of which he acts in the most extraordinary manner. In the latter—melancholia, or mania with depression—delusion may be absent, or, rather, for a time undetectable. The sufferer is gloomy, and troubled with unhappy thoughts, which sometimes lead him to self-destruction. He is sleepless, and rejects his food as unnecessary. He may be aroused for a short time by questions addressed to him; his replies to which are usually given correctly, most frequently in monosyllables; but the moment his questioner leaves him he relapses into his former gloomy state.

It may be as well to define in this place the difference between *a delusion* and *an illusion*.

> A *delusion* is a chimerical thought; an affection of the mind.
>
> An *illusion* is a perversion of the senses; a mockery; false show; counterfeit appearance.
>
> A *delusion* of the mind—an *illusion* of the senses.

Dr Taylor remarks that "hallucinations are those sensations which are supposed by the patient to be produced by external impressions, although no material objects act upon his senses at the time. Illusions are sensations produced by a false perception of objects. When the hallucination or illusion is believed to have a positive existence, and this belief is not removed either by reflection or by an appeal to the other senses, the person is insane; but when the false sensation is immediately detected by the judgment, and is not acted on as if it were real, then the person is sane."

Partial Intellectual Mania.—The term *monomania*, first suggested by Esquirol, is now generally given to

this variety of insanity. The patient, in the simplest form of this disorder, becomes possessed of some single notion, which is alike contradictory to common sense and to his own experience. Thus, he may fancy himself made of glass; and influenced by this idea, he walks with care, and in dread of being broken by contact with other bodies. In the case of an inmate at the City of London Asylum, the presence of a weasel in the stomach was stated by one woman. Esquirol mentions the case of a woman with hydatids in her womb, who believed that she was pregnant with the devil. Most of these strange fancies appear to be dependent on errors of sensation.

Monomaniacs are ready enough to declare their predominant idea; yet at times, and that without the occurrence of a lucid interval, they will as carefully conceal it. "In the simplest form of monomania, the understanding appears to be, and probably is, perfectly sound on all subjects but those connected with the hallucination. When, however, the disorder is more complicated, involving a longer train of morbid ideas, we have the high authority of Georget for believing that, though the patient may reason on many subjects unconnected with the particular illusion on which the insanity turns, the understanding is more extensively deranged than is generally suspected."

MORAL MANIA.

Pinel first drew attention to this form of madness. Prichard defines it as "consisting in a morbid perversion of the natural feelings, affections, inclinations, temper, habits, and moral dispositions, without any notable lesion of the intellect or knowing and reasoning faculties, and particularly without any maniacal hallucinations."

It is divided into—*General* Moral Mania. *Partial* Moral Mania.

General Moral Mania.—"There are many individuals," says Prichard, "living at large, and not entirely separated from society, who are affected in a certain degree with this modification of insanity. They are reputed persons of a singular, wayward, and eccentric character. An attentive observer will often recognise something remarkable in their manners and habits, which may lead him to entertain doubts as to their entire sanity; while circumstances are sometimes discovered on inquiry which add strength to this suspicion. In many instances it has been found that a hereditary tendency to madness has existed in the family, or that several relatives of the person affected have laboured under other diseases of the brain. The individual himself has been discovered to have suffered, in a former period of life, an attack of madness of a decided character. His temper and disposition are found to have undergone a change, or to be not what they were previously to a certain time; he has become an altered man, and the difference has perhaps been noted from the period when he sustained some reverse of fortune which deeply affected him, or the loss of some beloved relative. In other instances, an alteration in the character of the individual has ensued immediately on some severe shock which his bodily constitution has undergone. This has been either a disorder affecting the head, a slight attack of paralysis, or some febrile or inflammatory complaint, which has produced a perceptible change in the habitual state of his constitution. In some cases, the alteration in temper and habits has been gradual and imperceptible; and it seems only to have consisted in an exaltation and increase of peculiarities which were always more or less natural and habitual. Persons labouring under this disorder are capable of reasoning, or supporting an argument upon any subject within their sphere of knowledge that may be presented to them; and they often display great ingenuity in giving reasons for

the eccentricities of their conduct, and in accounting for, and justifying, the state of moral feeling under which they appear to exist. In one sense, indeed, their intellectual faculties may be termed unsound—they think and act under the influence of strongly excited feelings; and persons accounted sane are, under such circumstances, proverbially liable to error, both in judgment and conduct." (For interesting cases of this form of madness, see Ray's "Jurisprudence of Insanity.")

Partial Moral Mania.—In the case of the unfortunate sufferers from this malady, one or two only of the moral powers are perverted.

This division admits of several sub-divisions :—

Kleptomania. — A marked propensity to theft. "There are persons," says Rush, "who are moral to the highest degree as to certain duties, but who, nevertheless, lie under the influence of some vice. In one instance, a woman was exemplary in her obedience to every command of the moral law except one—she could not refrain from stealing. What made this vice more remarkable was, that she was in easy circumstances, and not addicted to extravagance in anything. Such was the propensity to this vice, that when she could lay her hands on nothing more valuable, she would often, at the table of a friend, fill her pockets secretly with bread. She both confessed and lamented her crime."

Pyromania.—This consists in an insane impulse to set fire to everything—houses, churches, and property of every kind and description.

Erotomania and Nymphomania. — This is known as amorous madness, and consists in an inordinate and uncontrollable desire for sexual intercourse. The unfortunate victims of this disease often express the greatest disgust and repugnance for their conduct.

Homicidal Mania.—In this form of madness the propensity to homicide is very great, and in most cases uncontrollable. In the case of the notorious Deeming, hanged in Australia in 1892, for the murder of his wife, an appeal was made from the finding of the Colonial Court by which he was tried to the Privy Council, on the ground of his being affected with homicidal mania. The plea was not sustained. (See the case of Henrietta Cornier, given by Prichard, Ray, and others.)

The following suggestions may be of assistance in forming a diagnosis as to the existence or non-existence of this form of madness :—

1. Previous history of the individual.—*Melancholy, eccentric, morose, etc.*
2. Absence of motive.—*Gain, Jealousy, revenge, hatred, etc.*
3. A number of victims are often sacrificed at one time.—*The murderer, on the other hand, seldom sheds more blood than is necessary for his success.*
4. Proceedings of the murderer before and after the crime.—*Absence of attempts at concealment or escape on the part of the madman.*
5. Character of the victims.—*Not infrequently, in the case of madmen, their victims are those whom, when sane, they loved most, and to whom they were most attached.*

Suicidal Monomania, or the Propensity to Suicide.—Much discussion has arisen on this subject. Suicide is not always the result of unsoundness of mind. Some, like M. Esquirol, are inclined to consider suicide as always a manifestation of insanity. In the present day, the dislike of Coroners' Juries to bring in any other verdict, but that of "suicide whilst in a state of unsound mind," is proverbial.

DEMENTIA OR FATUITY.

Dementia consists in a failure of the mental faculties, not congenital, but coming on during life. "A man," says Esquirol, "in a state of dementia is deprived of advantages which he formerly enjoyed. He was a rich

man who has become poor. The idiot, on the contrary, has always been in a state of want and misery." In this state there is always more or less incoherence, and maniacal paroxysms are not infrequent. In mania, incoherence may be present, but then it is characterised by sustained and violent excitement. In dementia, on the other hand, there is apparent torpor and exhaustion of the mental faculties. Closely allied to this form of mental unsoundness is that interesting disease known as "general paralysis of the insane," or perhaps a better term, *progressive paralysis of the insane.* It is considered by some to precede the psychical derangement, a contrary opinion being held by others. General paralysis may accompany any of the forms of mental derangement, but it is generally preceded by a stage of melancholy. As the paralytic affection becomes more marked, there is a concurrent loss of memory and incapability of mental association, and all sense of duty is lost; the patient becomes careless as to his person, and dirty in his habits. He expresses himself as possessed of great property, and boasts of the wonderful deeds that he can or has accomplished. Gradually he sinks into a state of complete mental and physical decay. He cannot give expression to his thoughts, and has to be fed, the food being pushed into his mouth. The symptom which first attracts the attention, and which is perhaps the first in order of sequence, is a modification in the articulation. "This is neither stammering nor hesitation of speech. It more closely resembles the thickness of speech observable in a drunken man. It depends upon loss of power over the co-ordinate action of the muscles of vocal articulation." If the tongue be now examined, it will be found that when it is protruded it is not inclined to one side, but that it is tremulous, and is protruded and withdrawn in a convulsive manner. Griesinger was the first to call attention to the fact, and his statement has since been confirmed, "that this motory disorder is at the commencement not so much

paralytic as convulsive in its nature." The gait becomes unsteady, the patient walks stiffly, and stumbles over the slightest unevenness in the floor. Step by step the paralysis progresses, till at last the unfortunate sufferer takes to his bed, on which he may lie for months. Sometimes, especially during the earlier stages, he may suffer from terrible delusions, from maniacal paroxysms, or from epileptic fits, the latter possessing certain peculiarities. The tongue during the fit is seldom bitten, which is so commonly the case in epilepsy; and the convulsions are not so general, being limited more to one side than to the other. It is also remarkable that each fit is in most cases followed by an increase of the mental derangement.

Prichard recognises four stages of dementia or fatuity :—

First Stage.—Forgetfulness and impaired memory.—This is common to old age. In most cases, passing events produce little, if any, impression, whilst the past is remembered with tolerable freshness.

Second Stage.—Incoherence and unreason, characterised by a total loss of the reasoning faculty.

Third Stage.—Incomprehension.—The person so affected is quite incapable of comprehending the meaning of the simplest question; and should he attempt to reply, his answer is generally remote from the subject.

Fourth Stage.—Inappetency.—The animal instincts are lost. The unfortunate sufferer lives, and that is all, being scarcely conscious of life. Organic life is all that is left.

DELIRIUM TREMENS. SIMPLE DELIRIUM. SOMNAMBULISM. SLEEP-DRUNKENNESS.

Delirium Tremens.—A temporary form of insanity, the result of excessive indulgence in spirituous liquors. The drunkard, under the effects of intoxication, "can derive no privilege from a madness voluntarily contracted, but is answerable to the law equally as if he had been in full possession of his faculties at the time" (1 Hale 32; Co. Litt. 247). The intoxication of the defendant may be taken as a mitigating circumstance,

showing that the deed was unpremeditated. A person rendered incapable of using his reason by intoxication brought about by others, is not liable for his actions.

Simple Delirium.—Acts performed during attacks of certain diseases—fever, sunstroke, etc.,—accompanied with delirium, do not render the individual liable to punishment; and wills made during the continuance of the disorder, if they contain no statement inconsistent with the known wishes and desires of the party during health, are valid, the law looking more to the good sense of the will as a proof of a lucid interval, than to the proved existence of such lucid interval.

Somnambulism, etc.—This is an abnormal mental state, closely allied to that artificially produced and known under the names of mesmerism, hypnotism, electro-biology, etc. It is commonly known as "sleep-walking." In this condition the mind appears to become enslaved by one train of ideas to the exclusion of all others; the somnambulist, thus deeply bent on the accomplishment of a definite end, takes no heed of those objects which are in no way connected with the dominant ideas in his mind. Hence, he walks safely past dangers which, when awake, would disconcert his judgment and weaken his will. Somnambulism appears also to be closely connected with epilepsy. In 1878, a man named Fraser was tried in Glasgow for the murder of his child by beating it against the wall. He was acquitted on the ground of being unconscious of the nature of his act by reason of somnambulism. He was sprung from an epileptic and insane stock; his mother died in an epileptic fit, and some of his other relatives were insane. Thus it appears, if the somnambulism be proved, the accused is exonerated from any responsibility connected with the act for which he is being tried. So also, if a person be suddenly aroused from a deep sleep—*somnolentia* or *sleep-drunkenness*,—

the question may be raised as to his responsibility for an act committed at the moment of awakening (R. *v.* Milligan). There cannot be a doubt but that if a person be suddenly aroused whilst dreaming, he may unconsciously commit acts, the outcome of his dream, which, unless the possibility of this condition be recognised, may entail severe punishment on him. This state is closely allied to that mental condition which sometimes occurs in epileptics immediately after a fit. But in this, as in cases of somnambulism, the facts of the case would have to be most carefully scrutinised.

The following hints may be of use as a guide in determining the responsibility or not of the accused :—

1. The person must be shown to have a general tendency to deep and heavy sleep, out of which he can only be aroused by a violent and convulsive effort.

2. Are there any circumstances which, happening before the individual went to sleep, would produce a train of disturbed thought not entirely composed by sleep?

3. Did the act occur during the usual hours for sleep?

4. Was the cause of the awakening sudden, and does the act bear throughout the character of unconsciousness?

5. What were the subsequent acts of the accused in relation to the deed? Did he try to evade responsibility? This must not have too much stress laid upon it, for the wretchedness of the sudden discovery may so overcome him, that he may seek to shelter himself from the consequences of an act for which he is legally but not morally responsible.

DIRECTIONS FOR SIGNING MEDICAL CERTIFICATES FOR THE RESTRAINT OF THE INSANE.

(*a*) In the case of pauper patients the signature of one medical man is alone required, but the order must be signed by a Justice of the Peace, or by the officiating clergyman and the relieving officer of the parish in which the lunatic for the time being resides. In cases of great emergency, a person, if not a pauper, may be received into an asylum or hospital upon a certificate signed by *one* medical practitioner, provided that within *three days* the proper certificates be duly signed and

delivered. To retain a person beyond the three days renders the keeper of the asylum liable to an action for misdemeanour.

(*b*) In all other cases—

1. The signatures of two medical men are required. Any one signing the certificate unless duly qualified is liable to a prosecution for misdemeanour (R. *v.* Ogilvy).

2. A relation or friend must also sign the order of admission into the asylum.

3. The medical men must not be in partnership, as principal and assistant, or have any direct or indirect interest in the patient or in his keeping (16 and 17 Vict., c. 96, sec. 4).

4. They must make separate visits, and at different times.

5. Each must write clearly in the proper place, on the form prescribed by law—(1) The facts observed by himself as evidence of insanity. (2) The facts observed by others as evidence of insanity. The name of his informer *must* be given.

6. The correct address of the patient and the date of the visit must be stated. The addresses of the certifying medical men must also be stated.

7. The certificate need not be filled up, signed, and dated on the day of examination of the patient, but the examination must take place within seven clear days of the admission of the patient into an asylum. Neglect of this rule invalidates the certificate (Hall *v.* Semple). The certificate remains valid for seven days; after the lapse of that time, before admission to an asylum can be obtained, new certificates must be procured.

8. Great care must be taken to follow carefully the marginal directions on the certificate form. The most trivial omission will invalidate the certificate, and in the case of Greenwood, the omission of the name of the street and the number of the house was held sufficient

to set it aside. A medical man should remember that, although his certificate may have passed the scrutiny of the Commissioners, it is liable to be made the subject of discussion in a Court of Law, and in cross-examination he will have to support the statements therein made. According to Dr Millar, of Bethnal House Asylum, very few of the medical certificates of insanity are properly filled up. I therefore copy the certificate, properly filled up by himself, and given in his little book on "Hints on Insanity."

MEDICAL CERTIFICATE PROPERLY FILLED UP.

1 *Here set forth the qualification entitling the person certifying to practice as a* physician, surgeon, *or* apothecary.

I, the undersigned, *John Millar*, being a (1) *Licentiate of the Royal College of Physicians, Edinburgh,*

2 Physician, surgeon, *or* apothecary, *as the case may be.*

and being in actual practice as a (2) *Physician,*

3 *Here insert the street and number of the house (if any), or other like particular.*

4 *Insert residence, and profession or occupation (if any).*

5 Lunatic, *or* an idiot, *or* a person of unsound mind.

hereby certify that I, on the *third* day of *November, One thousand eight hundred and eighty-eight*, at (3) *600 Cambridge Road, Bethnal Green*, in the county of *Middlesex*, separately from any other medical practitioner, personally examined *James Thompson, sen.*, of (4) *600 Cambridge Road, Bethnal Green, gentleman*, and that the said *James Thompson, sen.*, is a person (5) *of unsound mind*, and a proper person to be taken charge of, and detained under care and treatment; and that I have formed this opinion upon the following grounds, viz.:—

6 *Here state the facts.*

1. Facts indicating insanity observed by myself (6)—

He is incoherent in his conversation, violent in his conduct, and quite unable to take care of himself.

7 *Here state the information, and from whom.*

2. Other facts (if any) indicating insanity communicated to me by others (7)—

His son, James Thompson, jun., informs me that he has threatened to commit suicide, and has twice attempted it with a razor.

(Signed) Name—*JOHN MILLAR.*

Place of abode—*Bethnal House, Bethnal Green.*

Dated this *third* day of *November, One thousand eight hundred and eighty-eight.*

TABLE RELATING TO "FACTS" OF INSANITY. COMPILED FROM MILLAR.

FACTS OFFERING NO EVIDENCE OF INSANITY.	VAGUE AND IRRELEVANT FACTS.	GOOD FACTS.
1. Refuses to take her medicine and resists in every way; closes her teeth; threatens to strike every one near her; obliged to use the strait-waistcoat.	1. She is suspicious of her husband; says he keeps bad company; she is most irritable and jealous, and takes stimulating drinks to a dangerous and exciting extent.	1. She states that she is a lost person and without hope of forgiveness; that she will be taken to prison, and die a miserable death; that the devil whispers in her ear that she has committed the unpardonable sin.
2. Violent in her temper, and very abusive.	2. Obstinate; has the manner and appearance of an insane person; complained of her head; refused her food, and would not go down stairs; melancholy.	2. Great taciturnity; complete seclusion from society; aversion to cleanliness; wandering about the streets at improper hours.
3. Moody and irritable temperament, and of weak memory in many particulars.	3. He has imperfect sight; good hearing and taste; he is unable to speak; his gait is ape-like, and the skull-bones seem to have fallen together from the want of cerebral development. He will occasionally slap his face and strike his hands; sometimes makes a howling noise.	3. He states that he is a Prince of France; that he possesses a palace, and has recently had two fortunes left him (he cannot tell by whom)—one of £400,000, the other of £600,000; that he is going to Liverpool, a distance of 150 miles, with a horse and cart, which will take him four hours to go, and eight to return.
4. General restlessness of manner; considers himself heavily involved in debt to many thousand pounds; says he has been ruined by the Government, and that he intends prosecuting the Admiralty for £5000 damages.	4. She is very good-tempered; but day and night she talks almost incessantly; occasionally sings. She says she comes from Otaheite, and relates stories of those around her doing absurd things.	4. Inability to hold any rational conversation; her manner and conduct are totally at variance with her usual habits.

The following are examples of "Facts" sent back to be amended by the Commissioners—the emendations in italics :—

1. Incoherence, perversion of facts, delusion. *Fancies that he possesses large amounts of money which people have secreted from him.*

2. Says her sister lives in Chiselhurst, and she fears she is dying. She took great notice of my feet, and remarked that they were very large. Query by Commissioner—Are these delusions? *Her sister does not live at Chiselhurst, and is perfectly well; my feet are not large.*

3. General restlessness of manner; considers himself heavily involved in debt to many thousands of pounds, *whereas his debts do not amount to a few hundreds;* says he has been ruined by the Government, *whereas he has only been dismissed from his appointment on account of his incapacity;* and he intends prosecuting the Admiralty for £5000 damages, *he having no real ground of action.* (This was twice sent back for correction, the first correction being—*By these statements I was satisfied that the patient was of unsound mind, and by his general conduct during examination.* Finally amended as given above.)

LIABILITIES OF PERSONS SIGNING LUNACY CERTIFICATES AND RECEIVING INSANE PATIENTS.

In the case of Nottidge *v.* Ripley and Nottidge, the Lord Chief-Baron having been understood to intimate an opinion that no person ought to be so confined unless he is dangerous to himself or others, the Commissioners pointed out that the scope of the Lunacy Acts is not thus limited. They said—

"The object of these Acts is not, as your Lordship is aware, so much to confine lunatics, as to restore to a healthy state of mind such of them as are curable, and to afford comfort and protection to the rest. Moreover, the difficulty of ascertaining whether one who is insane be dangerous or not is exceedingly great, and in some cases can only be determined after minute observation for a considerable time.

"It is of vital importance that no mistake or misconception should exist, and that every medical man who may be applied to for advice on the subject of lunacy,

and every relative and friend of any lunatic, as well as every magistrate and parish officer (each of whom may be called upon to act in cases of this sort), should know and be well assured that, according to law, any person of unsound mind, whether he be pronounced dangerous or not, may legally and properly be placed in a county asylum, lunatic hospital, or licensed house, on the authority of the preliminary order and certificates prescribed by the Acts.

"Upon the whole, it appears that the power to restrain and confine a lunatic is limited at common law to cases in which it would be dangerous, either as regards others or himself, for the lunatic to be at large; but that the power to place and detain a lunatic in a registered hospital or licensed or other house, under an order and medical certificates duly made and obtained in accordance with the Lunacy Acts, is not so limited."

LIABILITIES OF PERSONS RECEIVING PATIENTS.

According to the Statute (see 8 and 9 Vict., c. 100, sec. 44), no person is allowed to receive more than one lunatic patient into his house, unless the house be licensed as an asylum; and the Statute further enacts that no person, unless he derive no profit from the care of the patient, or a Committee appointed by the Lord Chancellor, shall board or lodge any *one* patient in any house without the proper order and medical certificates. A licence for a house becomes necessary only where more than *one* patient is received.

It is also important to remember that if any one receive a person not insane at the time, but who subsequently becomes insane, he renders himself liable to prosecution, unless he procure the necessary medical certificates and order (R. *v.* Wilkins).

Is a Lunatic a competent Witness?—Mr Fitzjames Stephen maintains ("Criminal Law") that madmen

are competent witnesses in relation to testimony as in relation to crime. If they understand the nature of an oath, and the character of the proceedings in which they are engaged, they are competent witnesses whatever be the nature or degree of their mental disorder. An idiot shall not be allowed to give evidence (Co. Litt. 6 b.; Gilb. Ev. 144); a lunatic during a lucid interval may (Id. Com. Dig. Testm. [A]). When a lunatic is tendered as a witness, it is for the Judge to examine and ascertain whether he is of competent understanding to give evidence, and is aware of the nature and obligation of an oath; if satisfied that he is, the Judge should allow him to be sworn and examined (R. *v.* Hill, 2 Den. 255; 20 L.J. [M.C.] 222).

The Civil Rights of Lunatics.—If an individual be suffering from such mental disease as to render him incompetent to manage his own affairs, the law steps in to protect him and his property from injury. But the power so used does not necessarily imply that he is deprived of his personal freedom, but merely such restraint as is necessary for his protection.

Many lunatics, under the protection of the Court, live in their own houses with large establishments. A person so protected by the law is said to be subject to an "interdiction." In these cases a commission is usually granted by the Court of Chancery, and a writ known under the name of "*de lunatico inquirendo*" issued, after certain legal matters of detail are settled, and affidavits from medical men certifying to the insanity of the party have been filled.

The tests of insanity in these cases differ from those required in criminal cases, where the knowledge of right from wrong is imperatively demanded. The mental defect must not be the result of ignorance or want of education, and at one time commissions were only issued when it was shown that lunacy and idiocy alone

existed, imbecility or mere weakness of mind not being deemed sufficient to deprive a man of his civil rights, or to place him under the protection of the Court.

To so great an absurdity did this lead, that the man suffering from a delusion sufficient to be comprehended under the legal term "lunacy" was protected, whereas the feeble-minded were left without interference, though needing it more. The cost of these commissions sometimes reached almost fabulous sums. The expense has been somewhat lessened by recent enactments, and the process simplified—the Lord Chancellor having it in his power to direct an inquiry before two Commissioners, thus dispensing with a Jury. (See the 16 and 17 Vict., c. 70, and 25 and 26 Vict., c. 86.)

In Scotland, however, the law is far more simple. The cognition proceeds on a *brieve* or writ addressed to the Lord President of the Court of Session, and directs him to inquire "whether the person sought to be cognosced is insane, who is his nearest agnate, and whether such agnate is of lawful age." "And such person shall be deemed insane if he be furious or fatuous, or labours under such unsoundness of mind as to render him incapable of managing his affairs." "The trial is before a Judge of the Supreme Court and a special Jury. If the insanity be proved, the nearest agnate—relation by the father's side—is by law entitled to the guardianship." No one not a near relative can institute these proceedings.

In Scotland also, the trial by Jury may be avoided by applying by petition to the Court of Session for the appointment of a judicial factor or *curator bonis*. Of this appointment the alleged lunatic is informed, which, if he please he may oppose; medical evidence is received, and on this the Court rests its decision; the usual course being to remit the case to some competent person to make inquiry, take evidence, and report. The Commissioner is usually the Sheriff.

Examination of the Insane.—A few words of caution need here be said. Medical men will consult their own dignity and that of their profession by remembering that in cases of alleged insanity, as in fact in all other cases when their opinion is sought, they are not justified in taking sides. Their evidence will be the more valuable in proportion to the care they take in examining into the facts of the case, and the good sense and judgment shown in their examination of the patient. To distinguish between the mistakes, the result of ignorance and want of education, and those the result of a feeble mind, is of primary importance. It is no sign of insanity in an uneducated farmer that he knows not the *pons asinorum.* All cases should be tested by considering the surroundings and possible degree of culture of a person placed under like conditions as the party under examination. Has he shown himself capable of an average amount of culture? or is his mental condition inferior to what one might legitimately expect under the influences to which he has been subjected? The medical examiner should also direct his attention to this important point, setting aside all legal and medical theories of insanity, viz:—"Is the case of *such mental disorder* as to create *an incapacity for managing affairs.*"

DUTIES OF A MEDICAL OFFICER TO A UNION WITH REGARD TO LUNATICS.

Every medical officer of a Union district, on his becoming aware that any pauper resident in his district is, or is deemed to be, a lunatic and proper person to be sent to an asylum, must within three days give notice in writing to the relieving officer, or failing him, to the overseers, subject to a penalty not exceeding £10 for neglect. A medical officer, paid to visit a lunatic in his district, renders himself liable to a fine, if, for the sake of retaining the fee, he do not send such lunatic to an asylum when necessary.

TOXICOLOGY.

Toxicology is that division of Forensic Medicine which takes into consideration the modes, the actions, and also the methods of detecting poisons when occasion requires.

Poison.—Neither the law nor medicine defines a poison; but for all practical purposes, a poison may be defined as *any substance which, introduced into the system or applied to the body, is injurious to health and destroys life, irrespective of temperature or mechanical means.*

Administration of Noxious Drugs.—At a Bodmin Assize, Lord Chief-Justice Cockburn, after consultation with Mr Justice Hawkins, delivered an important judgment on this subject. A man was charged with having administered cantharides with a criminal intent. The Judges ruled that there must not only be an administration of an noxious drug with a guilty intent, but the drug must have been administered in such quantities as to be noxious, whereas the dose here given was too small to be seriously deleterious. Distinction was drawn between a drug like cantharides, which is only noxious when given in excess, and strychnine, a well-established poison. Acquittal was therefore directed.

Classification of Poisons.—A good and scientific classification of poisons is still wanted. The following may be taken as guides by the student:—

1. Inorganic. { *Corrosive*—Sulphuric acid.
  Irritant—Arsenic, etc.

2. ORGANIC.	*Irritant*—Savin, cantharides. *Affecting Brain*—Opium. *Affecting Spinal Cord*—Strychnia. *Affecting Heart*—Digitalis. *Affecting Lungs*—Carbonic acid.

(GUY.)

IRRITANTS.	*Mineral*	Acid poisons—Sulphuric acid. Alkaline poisons—Caustic soda. Non-metallic—Phosphorus, iodine. Metallic—Arsenic, antimony.
	Vegetable—Savin, elaterium, etc.	
	Animal—Cantharides.	
NEUROTICS.	*Cerebral*—Opium, hydrocyanic acid, alcohol. *Spinal*—Strychnia, nux vomica. *Cerebro-spinal*—Conia, belladona, aconite. *Cerebro-cardiac*—Calabar bean, digitalis.	

(TAYLOR.)

The subjoined classification is based upon that adopted by Professor Sir Douglas Maclagan, but for the arrangement of poisons under each group I am entirely responsible. I have tried to classify the poisons in accordance with the latest views as to the physiological action of each substance. Where the poison acts in such a manner as to place it in two or more groups, I have fully described it in one, merely drawing attention to it under the others:—

CHEMICAL.

Corrosive,	Acids. Alkalies. Caustic Salts.
Vulnerant,	Glass, Needles.

VITAL.

Irritant,	Metalloid,	Phosphorus, Iodine.
"	Metallic,	Arsenic, Antimony, etc.
"	Vegetable,	Gamboge, Elaterium.
"	Animal,	Cantharides.
Narcotic,	Somniferous,	Opium.
"	Deliriant,	Hyoscyamus, Belladonna.
"	Inebriant,	Alcohol, Cocculus Indicus.
Sedative,	Cardiac,	Digitalis, Aconite, etc.
"	Cerebral,	Ether, Chloroform.
"	Neural,	Conium.
Excitomotory,		Strychnia.
Irrespirable Gases,		Carbonic Acid, etc.
Toxicohæmic or Septic,		Snake Venom, etc.

Action of Poisons.—Amid the difficulties which surround this subject, three points appear to have been clearly made out:—(1) That it is necessary for all poisons to enter the blood before their specific action can be produced. (2) That poisons possess an elective affinity for certain tissues and organs. Thus, arsenic, however introduced into the system, as a rule, attacks the stomach; and this peculiarity of action closely allies it to the poisons of typhoid, scarlet fever, small-pox, etc., which appear to have, respectively, an elective affinity for the glands of the intestines, the throat, and the skin. (3) That the habitual use of a poison in medicinal doses does not ensure a perfect toleration on the part of the system with regard to the action of the poison, for that sooner or later a complete cachexia is produced, showing that the poisonous effect of the drug is not arrested.

Besides the above, there are also certain conditions connected with the action of poisons:—(1) The poison is absorbed and distributed by the blood. (2) A portion is eliminated by the fluid secretions and excretions. (3) Another portion is for a time deposited in the tissues and organs of the body. These processes are of necessity simultaneous.

The channels of entrance and exit are as follow:—Of entrance we have—(1) *The blood-vessels as a result of wounds*—more important as a physiological than in a medico-legal question. (2) *The skin and cellular membrane.*—Absorption by the skin is modified by the condition of the part, and also by the form in which the drug is applied. Thus the skin of the arm-pits and groins is more absorbent than the palms of the hands. Watery solutions are not so effective as oily preparations, and the application of the drug in fine powder is more effectual than a watery solution of it. This is explained by the presence of a natural oily, unctuous substance on the skin, which prevents the direct contact of the watery solution, but if the solution be allowed to evaporate on the part, the substance

thus left in minute division is then readily absorbed. The danger of allowing strong solutions of corrosive sublimate to evaporate on the head in the treatment of certain skin eruptions is thus explained. (3) *The lungs and air passages.*—Absorption by these organs is most active, hence the intense rapidity in the action of aërial poisons. (4) *The stomach and intestines.*—Poisons introduced into the stomach or intestines take longer to arrive at the special organs on which they act than by the other channels of entrance. They are absorbed by the capillaries and mesenteric veins, and before passing to the heart, by which they enter the general circulation, they pass through the liver, where they are in part excreted in the bile or deposited in the gland. The absorbing power of the stomach is modified by its fulness or emptiness, and poisons not soluble in water may be rendered so by the gastric secretion. Some poisons which act rapidly when entering by a wound, are inert when taken into the stomach. This, though true in some cases, does not always occur; and the inertness of these poisons, it has been suggested, may be due to the elimination of them being as rapid as their absorption, so that a poisonous dose never enters the circulation. The intestines absorb more rapidly than the stomach, and this must be borne in mind when administering powerful drugs *per anum.*

Of the channels of exit we have :—(1) *The kidneys.* (2) *The lungs.* (3) *The bile.* (4) *The milk.* (5) *The saliva.* (6) *Mucous membrane.* (7) *The skin.*

We know not the cause, but certain poisons appear to select a particular route for their exit—thus iodide of potassium leaves by the urine; mercury and its salts by the saliva; arsenic and eserine, the active principle of the Calabar bean, in small quantities, by the stomach, etc. We are, however, prepared to show that all poisons must enter the blood before they produce their effects, and that almost simultaneously with the entrance of

the poison into the blood a process of elimination begins, and that fatal effects depend upon absorption taking place more rapidly than elimination. On the amount also of the poison absorbed does its fatal effects depend, and not on the quantity actually taken. Whilst absorption and elimination are both going on, some of the poison is being deposited in the organs and tissues of the body. As proofs of these statements it has been shown that poisons have been detected in the blood, and that urine, saliva, and milk, fluids secreted from it, may contain portions of the poison taken, and produce dangerous symptoms when given to other animals. Poisons applied to the brain tissue, or to nerve trunks, do not produce symptoms, and the action of a poison may be arrested for a time by compressing by a ligature the main vessels of the limb under the skin of which the poison has been injected. After death no trace of the poison may be detected, the quantity taken being just sufficient to produce a fatal result, or elimination may be so rapid that, although death was directly due to the poison, any remains of its existence cannot be made out. This occurred in the case of Dr Alexander, who died from an accidental dose of arsenic, all the arsenic being eliminated in *seventeen* days—in another fatal case, in *seven* days (Taylor).

As evidence of the diffusion of poisons the following Table may be of use :—

Physiological.	Dilatation of the pupil in poisoning by belladona, hyoscyamus, etc. Contraction of the pupil in poisoning by opium, Calabar bean.
Physical.	*Taste*—Bitter taste to the secretions. Strychnia, picrotoxia. The milk of animals fed on wormwood may become bitter ; on colchicum, poisonous. *Smell.*—Prussic acid, tobacco, conia, etc. *Colour.*—Skin blackened by nitrate of silver, given internally.

N.B.—By the aid of the spectroscope the salts of lithium and thallium have been detected in the liver and other tissues.

Recapitulation of the Mode of Action of Poisons, and the Causes which Modify their Action.

MODE OF ACTION.

I. LOCAL.

1. Corrosion of the part to which the poison is applied.	Strong acid, alkali, etc.
2. Inflammation as the result of irritants applied to a part.	Arsenic, cantharides, etc.
3. Effects on the nerves of motion and sensation.	Dilatation of the pupil by belladona, by tingling of the tongue and skin by aconite, paralysis by conia.

II. REMOTE.

1. Common—not to be distinguished from the effects of injury or disease
2. Specific—peculiar to the poison itself.
   (1) General—affecting the whole system.—Antimony.
   (2) Partial—acting on a particular organ.—Antimony.

MODIFYING CAUSES.

1. Quantity.	1. Quantity of the poison increases its rapidly fatal action. 2. Action changed by the size of the dose. Thus, oxalic acid in large doses acts as a corrosive; in small doses on the heart, brain, or spinal cord.
2. Form.	*Solubility* increases the activity of poisons. *Chemical Combinations.*—Baryta is poisonous, sulphate of baryta is inert. *Mixture.*—Dilution may retard or accelerate the action of a poison.*

* Dilution lessens the activity of some poisons, by prolonging the time necessary for their absorption; but in the case of powerful irritants, which act through the blood, moderate dilution increases their activity, by enabling them to enter the vessels more easily. Oxalic acid is an example of the effect of dilution as a modifying agent in its action. A small concentrated dose acts as an irritant; diluted, it is soon absorbed, and quickly causes death.

3. Point of application—Skin, lungs, mucous and serous membranes.

4. Condition of the body.
- *Habit*—generally lessens the action of poisons, *e.g.*, *arsenic eater.*
- *Idiosyncrasy*—increases or may lessen the action of poisons.
- *Disease*—generally lessens, but in some cases increases the action of poisons.

GENERAL EVIDENCE OF POISONING.

It will now be necessary to consider briefly the general evidences of poisoning, in order to determine whether a death alleged to be due to poison is not really the result of disease. For convenience of description, this subject will be divided into five sections.

1. Evidence from the Symptoms.
2. Evidence from the *Post-mortem* Appearances.
3. Evidence from Chemical Analysis.
4. Evidence from Experiments on Animals.
5. Moral Evidence.

1. Evidence from the Symptoms.—As a general rule, except in cases of slow poisoning, when the poison may be so administered as to simulate disease, the symptoms come on suddenly, while the person is in apparent health. In cases of suspected homicide, this suddenness in the accession of the symptoms is particularly to be noticed, and we may have to decide as to the probabilities of accident, suicide, or homicide. Here collateral evidence must be our guide. The slowness, obscurity, and irregularity of the symptoms are more in favour of homicide than either accident or suicide. But it must also be borne in mind that the invasion of many diseases is sudden, as is the case with cholera, gastritis, and some others.

Certain conditions of the system more or less modify the effects of some poisons. Thus, sleep delays the

action of arsenic; and this may also be the case with other poisons. Intoxication has also been said to exert a retarding power over the action of certain poisons. This is probably more apparent than real, the fact being that the symptoms in the cases observed are masked.

Much more important, however, is the influence of disease. Large doses of opium are well borne in mania, delirium tremens, dysentery, and tetanus; whereas it is well known that even small doses of mercury in cases of Bright's disease of the kidney, or in children recovering from any of the eruptive fevers, have produced dangerous salivation.

The symptoms of poisoning go on from bad to worse in a steady course; but there may be remissions, followed, under treatment, by their entire disappearance, no ill effect remaining. Remissions are most likely to occur in slow poisoning with the metallic irritants from fear of detection or cunning on the part of the poisoner to imitate the progress of disease. In nervous affections, all the symptoms must be taken into consideration, and these will be found to differ from those of any known poison. The history of the case should also have due attention paid to it.

In poisoning, the symptoms appear soon after food or drink has been taken. This is open to the objection that apoplexy has occurred immediately after a meal. The probative value of the above statement is, however, increased if several persons have been similarly affected after partaking of the same dish, especially if the symptoms followed within a short time—under four hours—of the meal. But it must also be remembered that all persons are not affected alike by the same poison. A whole family may be attacked with symptoms which point strongly to the use of poison, and yet death may be the result of disease, or of some irritant substance generated during the process of cooking. Rebaked pie-crust has been known to cause severe diarrhœa and colic. Again, the diagnostic value is weakened if it

can be proved that the person or persons affected have taken nothing in the way of food for two or three hours previously.

The flesh of animals poisoned by accident, or intentionally, may seriously affect those who eat it.—As a case in point may be mentioned the injurious effects produced in some persons who had partaken of the Canadian partridges imported to this country some years ago, and which had probably eaten of some poisonous berries during the severe winter of that year.

Poisons may be introduced into the system otherwise than by the mouth; that is, they may be placed in the vagina or rectum, or inhaled when volatile poisons are used. Sometimes a poison has been introduced into the medicine, or a poisonous draught substituted for the one prescribed. In any case, where suspicious symptoms suddenly occur, the poison has most probably been taken in from half-an-hour to an hour previously, and it is of special importance to note the period of time that may have elapsed between the accession of the symptoms and the last meal, or administration of medicine.

When called in to a case of suspected poisoning, and in many cases where no suspicion at the time arises, the medical attendant should pay attention to the following points:—

1. The time of the occurrence of the symptoms, and their character.
2. The time that has elapsed between their commencement and the last meal, dose of medicine, etc.
3. Have the symptoms continued without intermission or remission, and in an aggravated form, till death?
4. The order of their occurrence.
5. The previous health or illness of the patient.
6. Have the symptoms any relation to a particular meal or article of food, etc.?
7. If patient has vomited, have the vomited matters, especially the first, been carefully preserved?
8. Preserve all vomited matters, food, medicines, etc.
9. How many were at the meal? and what was taken common to all or only by a few?

2. **Evidence from *Post-mortem* Appearances.**—The morbid appearances found in cases of poisoning will be treated more in detail when each poison, or group of poisons, comes to be separately considered. A caution may be given here against allowing the *post-mortem* signs of disease or external injury to exclude the idea of poisoning; for death may to all appearance be the result of disease or injury, and yet be caused by poison. An attention to the *post-mortem* appearances is important in all cases; for in many instances, where the symptoms were unknown to the experts at the time the inspection was made, they were subsequently found to correspond with the morbid changes which the autopsy revealed. The normal appearance of the stomach is white or nearly so, except during digestion, when it is reddened ; yet we may sometimes come across cases in which the mucous membrane of this organ may be found so reddened as to lead to a suspicion of poisoning. The knowledge of this fact, and the absence of symptoms will prevent an error in diagnosis. Ulceration from disease and from irritant poisoning must be distinguished. In that due to disease, the ulcers formed are, as a rule, small and circumscribed ; in those from poison, there is diffused inflammatory redness over other parts of the stomach, and even in the intestines ; and the poison, as in the case of arsenic, may be found adhering to the sides of the ulcer. Ulceration is more frequently the result of disease than of the action of poisons. Perforation of the stomach or intestines may be due to ulceration or to corrosion. The condition of the mouth and gullet will help the diagnosis. The appearance of the ulcer and the parts around it, together with the hints just given, must guide the diagnosis. Of *post-mortem* softening little need be said, beyond stating that it very rarely occurs, and is of course not preceded by symptoms. (For the diagnosis between inflammatory redness of the intestines and *post-mortem* staining, see page 33.)

3. **Evidence from Chemical Analysis.**—The objects of a chemical analysis are to determine:—(1) The presence and nature of the poison. (2) The proportion or quantity of the poison taken. (3) The solution of certain questions connected with the administrations of the poison.

The detection of poison in the body is of course the most important proof of poisoning; but it may be suggested that the poison was introduced after death, which, to say the least, is a most ingenious line of defence, but which, at the same time, must be held to be highly improbable, and impossible if found deposited in one or more of the solid organs. Again, granting that poison has been taken, is it the cause of death? This question may arise when injuries are found on the body, and it then becomes a matter of importance to know something of the symptoms which preceded death, and the morbid appearances found after death. The case of the girl who took arsenic to escape a beating by her father, is a case in point. The father was tried for causing the death of the girl by undue severity, but it was subsequently shown that arsenic self-administered was the true cause of death. The poison may disappear from the body. This disappearance may be effected by vomiting, purging, or by the urine, or the poison may become absorbed and decomposed. The person poisoned may live sufficiently long to allow of the entire elimination of the poison, and yet die of the induced exhaustion. (See case of Dr Alexander, *ante.*)

Some poisons, especially those which are sparingly soluble, are with difficulty removed from the stomach, even by the most incessant and violent vomiting. This is notably the case with arsenic, which adheres to the mucous coat of the stomach with considerable tenacity. But even after all traces of the poison have left the stomach, it may be detected in the solid viscera.

Temporary deposit of poison in the organs of tissues (TAYLOR) :—(1) The Liver. (2) The Kidneys. (3) The Spleen. (4) The Heart. (5) The Lungs. (6) The Muscles. (7) The Brain. (8) The Fat. (9) The Bones.

With regard to arsenic, the following Table, taken from Taylor, is of importance, as showing the amount of the poison which may be found in the liver at certain intervals :—

After taking the Poison.	Total weight of Arsenic.
In 5½ to 7 hours,	0·8 grains.
8¾ hours,	1·2
15 hours,	2·0
17 to 20 hours,	1·3
10½ days,	1·5
14 days,	0·17
17 days,	*nil.*

Is it necessary that the poison should be found in the body or in the evacuations, to lead to a conviction for poisoning? On this point, Christison was of opinion that if the symptoms, *post-mortem* appearances, and moral evidence are very strong, it is not necessary that the poison be found in order to establish a charge of poisoning. This opinion was also supported by the late Dr Geoghehan, Professor of Medical Jurisprudence in the Royal College of Surgeons, Ireland, and was also virtually acted upon in the case of Palmer, where the non-detection of strychnia was strongly dwelt upon by the counsel for the defence, but without success. Many of the vegetable poisons almost defy detection, except by the symptoms, *post-mortem* appearances, and some experiments on animals of doubtful value. The detection of poison in the food taken, or in the vomited matters, is of great importance; but it is of still greater importance if it can be found in the urine, drawn from the bladder, this being a proof that it has passed through the system. Here again a caution is necessary—for it must be remembered that poisoning may be *feigned* or *imputed*—the poison being mixed with the food and evacuations, and an innocent person accused.

The following suggestions should be carefully considered by every analyst when substances are sent to him for examination :—

He should carefully note when and from whom the substances were received; in what state they were received—secured, or exposed; the number of articles, and whether properly labelled. He must make the analysis himself, and state where it was made. The character and nature of the substances examined should be noted, and he must be prepared to give an outline of the methods or processes used for their determination. He must also be able to guarantee the purity of his reagents, and be prepared to answer the following questions :—

1. Is the poison free or combined?
2. What is the strength and quantity found?
3. Could the poisonous substance exist naturally?
4. How much of the poison found is a fatal dose?
5. If no poison is found, is there anything noxious or injurious to health?

The analyst may have the following submitted to him for examination :—(1) Substances found on the accused, or in the room, or on the person of the deceased. (2) Articles of food. (3) Vomited matters, urine, etc. (4) Contents of the stomach. (5) Solid organs of the body.

He may also have his results called in question for the following reasons :—(1) Purity of his reagents. (2) Faulty processes. (3) Hasty conclusions. (4) Experiments on animals.

Death may undoubtedly be due to the action of a poison, and yet its presence may fail to be detected, due to—(1) The nature of the poison—strychnia, hydrocyanic acid, etc. (2) Vomiting and purging. (3) Absorption and elimination. (4) Decomposition —phosphorus, chloral hydrate, chloroform. (5) Smallness of the dose.

(For directions for conducting a *post-mortem* examination in cases of poisoning, see page 52.)

4. **Evidence from Experiments on Animals.**—The evidence derived from experiments on animals with the contents of the stomach and vomited matters must not be too implicitly trusted, as these may give rise to vomiting and other symptoms when no poison is present. All animals are not alike affected with man by the same poisons; and it appears that the dog and the cat are the only animals that at all approach man with regard to the effects produced. Experiments on the lower animals are useless to decide—(1) The fatal dose of any poison. (2) The rate of absorption, deposition, or elimination of poisons. (3) The rapidity of the action of certain poisons.

In the case, however, of some vegetable poisons, the effects produced on animals by a portion of the substance taken by the person suspected of having been poisoned, may afford corroborative evidence of poisoning. In the case of Lamson, executed for poisoning his brother-in-law with aconite, experiments on animals formed the chief evidence against the accused. Of late, attempts have been made to prove the existence of certain cadaveric alkaloids or *ptomaïnes*, which give reactions not unlike those of some of the poisonous vegetable alkaloids. These *ptomaïnes* are supposed to be formed after death, or developed during life under the influence of certain morbid processes. They may be substitution products of a poisonous nature developed by "germs" out of existing harmless substances in the body. The question of their existence was raised in the above mentioned trial. (See also "*Annales D'Hygiène Publique*," July 1881, page 9.)

5. **Moral Evidence.**—The moral evidence of poisoning is generally furnished by the common witnesses of the Crown; but the value of this kind of evidence, in many cases, can only be fully appreciated by a medical witness. To render this part of the subject as complete as possible, a few remarks may not be out of

place. The suspicious conduct of the prisoner before and after the event, the recent purchase of poison, the mode of administration, the object of the prisoner in getting rid of his supposed victim, and the fact of several persons being alike affected, should be carefully noted down. The anxiety evinced during the illness of the deceased, and the hurry in the funeral arrangements, as showing an over-anxiety to remove all traces of his guilt, are suspicious. The probability of suicide is weakened by the state of the mind and the nature of the dying declarations of the deceased. In the case of a person indicted for poisoning, evidence to show motive in another case is admissible. (R. *v.* Geering, 18 L.J. [M.C.] 215; R. *v.* Heeson or Johnson; R. *v.* Garner, 3 F. and F. 681.)

Lastly, it remains to be considered—

What is the duty of a Medical Man who suspects the Action of Poison in a Patient on whom he is in attendance?

In the case of R. *v.* Wooler, Baron Martin, who tried the case, in his charge to the Jury, stated that, in his opinion, the medical men in attendance ought, "when the idea of poisoning struck them, to have communicated their suspicion to the husband, if they did not suspect him; and if they did suspect him, they ought to have gone before a magistrate." Suppose they had acted as the learned Judge suggested, and spoken to the husband, who, had he been guilty would in all probability, have desisted from his terrible design for a time, and a great criminal would have been let loose on society, and without punishment. Then, again, had they applied to the magistrates, the delay caused by the indecision of the magistrates how to act in so delicate a case would have allowed the criminal to remove all traces of his design, and the means of testing their suspicions would have been lost; and, along with this, would have been lost the professional character and

fortunes of the authors of the investigation. "There is a third course," said the late Sir R. Christison, "and in my opinion it is the fittest of all:—When the medical attendant is satisfied of the fact of poisoning, he should communicate his conviction to the patient himself. His predicament, in every other way, is so embarrassing, that he ought not to be deterred by the chance of injury to his patient from making so dreadful a disclosure." (See an account of the same course being adopted in the case of Mr Blandy by his physician, Dr Addington, reported in Howell's "State Trials," vol. xviii.)

Summary of the General Evidence of Poisoning, in a Tabular Form.

POISON.	NATURAL CAUSES.
1. The symptoms come on suddenly, and rapidly progress.	1. Many diseases come on suddenly—cholera, gastritis, etc.—and run a rapid course to a fatal termination.
2. The symptoms begin while the person is in sound health.	2. Some acute diseases begin under like circumstances.
3. The symptoms of poisoning go on from bad to worse in a steady increase.	3. This is also the case with many common diseases.
4. Uniformity in the nature of the symptoms.	4. The uniformity of the symptoms is common to many diseases; but in some cases the absence of uniformity may be a proof of disease.
5. The symptoms come on immediately after a meal.	5. Apoplexy, colic, cholera, and some other diseases, may follow a meal. But the fact that some hours have elapsed since the last meal is against the probability of poisoning.
6. Several persons are attacked, after partaking of the same meal, with the same symptoms.	6. As a general principle it may be stated that there is no disease likely to attack several persons at once, but there are cases on record of this having occurred.
7. Poison found in the food, vomited matters, urine, etc.	7. Poison may be mixed with the food, etc., in cases of imputed poisoning.

TABLE giving the names of Diseases whose Symptoms resemble those the result of Irritant Poisons, together with such Points of Difference as may assist in distinguishing the one from the other :—

IRRITANT POISON. — Symptoms of violent irritation in one or more portions of the alimentary canal. Pricking and burning of the tongue and mouth, and intense thirst, frequently accompanied with great constriction in the throat. Great abdominal pain and tenderness. Vomiting and purging are also usually present. The skin is hot and cold at intervals ; the pulse small, frequent, and irregular. In the last stage the skin may become icy-cold. *An acrid, metallic, or burning taste in the mouth precedes the vomiting.* The vomit and alvine discharges are generally mixed with *blood.* Death occurs in from six hours to two days and a half.

CHOLERA.—Extreme and sudden prostration. The breath is cold to the hand in the last stages. The body is cold, shrivelled, and livid, or of a leaden hue. Vomiting and purging are present ; the former is never bloody, the latter resembling rice-water. The thirst is intense, and in this particular alone resembles the effects of irritant poison. Death in from one to two days, or even less.

ENGLISH CHOLERA. — In this disease all the symptoms of irritant poisoning are present. Pain in the belly, and vomiting. But in this disease the vomit and alvine discharges are *never* bloody, most frequently bilious. *An acrid taste in the mouth and throat succeeds the vomiting.* This is due to the acrid nature of the vomited matters. The stools contain bile in English cholera ; in irritant poisoning, sometimes blood. Death is rare within three days.

GASTRITIS.—Acute idiopathic gastritis is so rare in this country as scarcely to need description. Most of the cases recorded of acute gastritis have been found to be due to irritants. We must, therefore, consider the period and order of the occurrence of the symptoms in relation to the last meal. Costiveness of the bowels would point to the presence of gastritis or enteritis, violent purging and vomiting to irritant poisoning.

ENTERITIS.—Though more common than gastritis, enteritis is a rare disease. The bowels are generally *confined.* Tubercular and aphthous inflammation of the intestines may simulate irritant poisoning, especially chronic poisoning by arsenic. The *post-mortem* and a chemical analysis will reveal the true cause of death.

PERITONITIS.—In the early stages of the disease vomiting is rare, and constipation is the rule, with marked tenderness over the whole abdomen. The morbid appearances in the peritoneum are seldom caused by irritants.

PERFORATION OF THE STOMACH. — The symptoms supervene immediately after a meal ; the pain, which is very acute, gradually extending over the abdomen. In most cases the patient has suffered for some time previously from dyspepsia.

Hernia.—Examine the seat of pain, the cause will be soon detected. But an omental hernia may be present, giving rise to twisting pain at umbilicus. The *post-mortem* will decide.

Intussusception of the Bowels.—Pain, sudden and confined to one spot below the stomach. Vomiting is present *without* purging, thus differing from diarrhœa and cholera. After a time the vomit becomes fæcal.

Colic. — May be confounded with poisoning by the salts of lead. If lead be taken in large doses, it produces the symptoms common to irritant poisons added to those of colic. In chronic lead poisoning, the blue line round the gums, the aspect of the patient, and history of the case, will point to the true cause of the symptoms. Lead colic is also generally accompanied with extreme depression of spirits.

Internal Rupture of Organs. —Rupture of the stomach, duodenum, gall bladder, and impregnated uterus, is of rare occurrence. The autopsy will show the true cause of death.

Table giving the names of Diseases whose Symptoms resemble those the result of Narcotic Poisoning, together with such Points of Difference as may assist in distinguishing the one from the other :—

Narcotic Poisoning. —Giddiness, headache, drowsiness, and considerable difficulty in keeping awake. Paralysis of the muscles, convulsions, ending in profound coma and death. The symptoms of narcotic poisoning begin not later than an hour, or at most two hours, after the poison is taken, except in the case of poisonous fungi and spurred rye, when a day or two may elapse. The symptoms of narcotic poisoning advance gradually. The person may, in *most* cases, be roused from the deepest lethargy. The pupil in opium-poisoning is, as a rule, *contracted.* Recovery seldom occurs after twelve hours ; in most cases, death takes place in six or eight hours—the shortest time being three hours.

Apoplexy.—In some cases apoplexy is preceded by warning symptoms — headache and giddiness. As a rule, apoplexy is a disease of old age, and of stout, plethoric people. If the symptoms do not come on for some hours after food or drink has been taken, this disease is to be suspected ; but it may occur *at* or *immediately* after a meal, too soon to be the result of the action of narcotics— ten to thirty minutes always elapsing before these poisons act. Apoplexy generally comes on suddenly, coma at once present. It is seldom possible to rouse the person when the sopor of apoplexy is fully developed. The pupils in apoplexy are *usually dilated* ; but should the effusion of blood take place into the pons Varolii, the pupils may be contracted, hence closely simulating opium poisoning. Apoplexy may last for days, or death may occur in an hour.

Epilepsy.—Loss of consciousness and presence of convulsions mark this disease; and in these it resembles poisoning by prussic acid. Epilepsy is in most cases a chronic disease. Warnings—*aura epileptica*—are often present. The fit begins violently and abruptly. The paroxysm generally lasts for some time, and death rarely occurs during the first attack.

Table showing Points of Difference in the Action of Corrosive and Irritant Poisons.

CORROSIVES.	IRRITANTS.
1. Destruction of the parts to which they are applied. No remote action on the system.	1. Irritation of the parts to which they are applied producing inflammation. Remote action present in most of the irritants.
2. Symptoms supervene immediately they are swallowed, and consist of a burning, scalding pain felt in the mouth, gullet, and stomach.	2. Symptoms may rapidly supervene after they are taken, or some delay may occur, due to the state of concentration or dilution of the poison. Pain in the stomach and bowels, more or less severe, is always present with the other signs of irritation.
3. Death may result from— (1) Shock. (2) Extensive destruction of the parts touched. (3) Starvation. (4) Suffocation, the result of œdema, or spasm due to acid in larynx.	3. Death may result from— (1) Shock. (2) Irritation, causing convulsions. (3) Protracted suffering. (4) Starvation.
4. *Post-mortem* appearances: corrosion and extensive destruction of tissue.	4. *Post-mortem* appearances: irritation, and signs of inflammation, ulceration, etc.

CHEMICAL.

CORROSIVE.

The Mineral Acids.

General Characters.—The mineral acids have no remote effects on the system; their action is purely local. They are seldom used for the purpose of

homicide, except in the case of young children. By suicides they are more frequently employed.

The **Symptoms** common to the action of these acids supervene *immediately* the acid is swallowed, and consist in a sensation of burning in the mouth and gullet. Dreadful pain is felt in the stomach, attended with constant eructations, and vomiting of a brownish or blackish matter, mixed with blood. Mucus, together with, in severe cases, portions of the mucous membrane of the stomach, may be detected in the vomited matters, which have an intensely acid reaction, changing the colour and destroying the texture of cloth or other material on which they may fall. The act of swallowing is attended with intense pain, and not infrequently is rendered quite impossible. The thirst is intense, the bowels are confined, and the urine is diminished in quantity. The pulse is small and weak, and the skin clammy and cold. Respiration is performed with difficulty, and the countenance expresses the most intense anxiety. Sometimes, when the upper part of the windpipe is implicated, there is more or less cough and difficulty of speech. Death may even result from suffocation—the skin, in this case, presenting a cyanosed appearance. The mouth is excoriated, the lips shrivelled and blistered. In children, when the acid has been poured far back into the mouth, by forcing the bottle backwards before emptying it of its contents, the mouth may more or less escape injury, and the signs in it of corrosive poisoning be absent. The teeth may become loose, and fall out of the mouth. The mental faculties remain clear, death generally coming on suddenly, the patient dying convulsed or suffocated. The period at which death ensues is very variable, and considerable power for locomotion may be retained by the sufferer, though, as a rule, he is found writhing in exquisite agony on the floor or elsewhere. Some cases recover, leaving the coats of the stomach more or less injured, and the general health greatly impaired.

Post-mortem Changes.—The body externally is healthy. The lips and external parts of the body, which have come in contact with the acid, are charred. The mucous membrane of the mouth, shrivelled and eroded, is whitish, yellowish, or brownish, sometimes appearing "as if it had been smeared with white paint" or thin arrowroot. Many of the appearances above described will depend upon the rapidity with which death has followed the swallowing of the poison. The mouth, gullet, and trachea may alone show any signs of the corrosive action of the poison, and it is important to remember that death may be due to sulphuric acid, and yet the acid may never have reached the stomach. In one or two cases where the poison was poured into the mouth during sleep, and in the case of children in whom the mouth was held open, there were no signs of the poison on the lips, and the mouth even escaped in one or two cases. The stomach, in some cases more or less contracted and perforated by the corroding action of the acid, may contain a dark grumous liquid, the acidity of which will depend upon the treatment adopted, or the length of time that may have elapsed from the swallowing of the acid to the fatal termination. The stomach also appears as if carbonised, this being due to the action of the acid on the effused blood; no such appearance being produced when sulphuric acid is poured into the dead stomach. In cases where the patient has survived from sixteen to twenty hours, the small intestines have been found inflamed. The blood, Casper states, is never fluid in acute poisoning by sulphuric acid, but always "syrupy at least, and sometimes ropy; it has a cherry-red colour, and acid reaction." Sulphuric acid is also said to possess powerful antiseptic properties, and that bodies of those who have died from its effects remain long fresh.

There are two things which may render the diagnosis difficult—(1) Gastric ulcer. (2) *Post-mortem* digestion of the stomach.

Gastric ulcers vary in size from that of a fourpenny piece to that of a florin, or larger. In shape, they are round or oval, and present the appearance of shallow but level pits, with sharp, smooth, vertical edges—appearing as if they had been punched out. The peritoneal opening is smaller than that on the internal surface of the stomach. The absence of injury to the mouth and gullet will distinguish gastric ulcer and *post-mortem* softening from the action of corrosive poisons.

General Treatment.—Chalk, carbonate of magnesia, the plaster from the walls or ceiling of the apartment stirred in water, and followed by diluent drinks—barley water, linseed tea, etc. The use of the stomach pump is contra-indicated.

SULPHURIC ACID.

Forms.—Sulphuric acid occurs in two forms—*concentrated* and *diluted.*

Characters.—Concentrated sulphuric acid or oil of vitriol (specific gravity, 1·800 to 1·845), as it is found in commerce, is a heavy, oily, colourless, or slightly brownish-coloured liquid, not fuming when exposed to the atmosphere; but, when added to water, causing a rapid increase of temperature, which may crack the glass vessel in which the mixture is made. Sulphuric acid chars and destroys the texture of organic bodies placed in it. *Dilute sulphuric acid* is a colourless, strongly acid liquid, reddening litmus, and charring paper dipped into it when subsequently dried, care being taken not to scorch the paper.

Symptoms, etc.—The symptoms and *post-mortem* signs have been already described, page 241, *et seq.*

Chemical Analysis and Tests.—The acid will have to be examined under the following heads:—(1) Simple, concentrated acid. (2) Dilute acid. (3) Mixed with organic liquids, food, vomit, etc. (4) On the clothes of the person injured.

I. CONCENTRATED ACID.

1. *Chars Organic Matter.*—A piece of wood or paper placed in the strong acid rapidly becomes blackened.

2. *Heat when added to Water.*—Equal quantities of acid and water added together produce intense heat.

3. *Evolution of Sulphurous Acid.*—When boiled with chips of wood, copper cuttings, or mercury, fumes of sulphurous acid are evolved, detected by their sulphur-like odour, and by their power of first bluing and then bleaching starched paper dipped in iodic acid.

II. DILUTE ACID.

1. *Chars Paper.*—This only occurs when the paper is dried by the aid of heat, subsequently to moistening it in the dilute acid.

2. *Precipitation of Sulphate of Barium.*—A solution of the nitrate or of the chloride of barium is precipitated by sulphuric acid in the form of a white insoluble powder, unaffected by nitric or hydrochloric acid, even when heat is applied. This test is so delicate, that a liquid containing $\frac{1}{25000}$th part by weight of the acid is precipitated by either of the test solutions.

3. *Action of Heat.*— The dilute acid is entirely volatilised by heat.

III. MIXED WITH ORGANIC LIQUIDS, ETC.

In tea, coffee, or beer, the mode of applying the tests are the same, the mixture being previously filtered, or the acid separated from the organic mixture by dialysis. The following cautions are necessary :—

Objection A.—Alum, or any acid sulphate, would give all the reactions with the nitrate and chloride of barium.

Answer A.—Evaporate a portion of the doubtful liquid; if pure acid, there will be no residue, sometimes only the *slightest trace* of sulphate of lead.

Objection B.—Erroneous estimation of free sulphuric acid, in consequence of the presence of some saline or neutral sulphates.

Answer B.—Evaporate as before. The free sulphuric acid separated by warning, the liquid is then added to a known weight of powdered carbonate of baryta until effervescence ceases. The resulting precipitate, when weighed, represents the free sulphuric acid present.

Calculate in the following manner—

$$Ba,CO_3 + H_2SO_4 = Ba,SO_4 + H_2O + CO_2.$$
$$Ba,CO_3 = 197.$$
$$H_2SO_4 = 98.$$
$$CO_2 = 44.$$

In the above equation, 98 parts of H_2SO_4 take the place of 44 parts of CO_2. If, therefore, 100 grains of Ba,CO_2 renders the liquid neutral, the amount of free SO_4 present will be represented by the increased weight of the precipitate in the proportion of 54 to 98, the difference between 44 and 98 the equivalent of $CO_2 + SO_4$.

IV. STAINS ON THE CLOTHES, ETC.

1. The strong acid changes the colour of black woollen cloth to a dirty brown, the edges of the spots assuming a reddish tint after a few days. The dilute acid on the same cloth produces a red stain, which in time becomes brown.

2. The spots made by the strong acid remain damp for some time; strong sulphuric acid having a great affinity for water, continually absorbs moisture from the atmosphere.

3. The spot should be cut out, boiled in distilled water, filtered and tested for free sulphuric acid.

4. A portion of the cloth not touched by the acid should be tested, in order to show that the sulphuric acid found is not due to sulphates present in the cloth.

5. An acid sulphate—bisulphate of potash—gives a reddish stain to black cloth like that produced by the dilute acid. Test for this salt by incineration.

Fatal Period.—Average time before death ensues is from two to twenty-four hours. The shortest time was one hour, but in children death may be instantaneous. Life, however, may be prolonged for some weeks, or even months.

Fatal Dose.—One drachm in a healthy adult has proved fatal; on the other hand, however, four ounces have been swallowed without being fatal.

Treatment.—As before mentioned.

N.B.—This acid of late years has given rise to several actions, it having been employed to disfigure the person by throwing it in the face.

NITRIC ACID.

Forms.—Strong nitric acid, and dilute nitric acid.

Characters.—This acid is commonly known as *aqua fortis*, or red spirit of nitre. It is seldom used as a poison.

The *strong acid* varies in colour from a pale yellow to a deep orange. The colour is due to admixture with peroxide of nitrogen. On *cloth* and *articles of dress* it produces *yellow stains*, which are darkened by the application of an alkali. If poured on copper cuttings, reddish fumes of nitrous acid are given off. *Dilute nitric acid* is a colourless acid liquid, not precipitated by nitrate of barium or nitrate of silver, showing absence of sulphuric and hydrochloric acids. All its alkaline salts are soluble in water.

Symptoms.—The symptoms have been before described, and are similar to those produced by sulphuric acid, though not quite so severe. The *vapour* of this acid has caused death in eleven hours by congestion

of the bronchial tubes and lungs; care should, therefore, always be taken not to inhale the fumes given off by the acid in the manufacture of gun cotton, etc.

Chemical Analysis.—Nitric, like sulphuric acid, will be examined under four heads; but being a volatile acid, easily decomposed, and also having its nature changed by contact with organic substances, its presence on clothes may fail to be detected after a few weeks. The colour of the stain on cloth may also remain, although the acid has been entirely removed by washing. 1. Strong, concentrated acid. 2. Dilute acid. 3. Mixed with organic liquids, etc. 4. On the clothes of the person injured.

I. CONCENTRATED ACID.

1. *Volatility.*—When exposed to the atmosphere, strong nitric acid gives off colourless or orange-coloured acid fumes. Heated in a watch-glass, it is evaporated without residue.

2. *Action on Organic Matter.*—The acid leaves on woollen clothes a *yellow-coloured stain*, which is darkened by the addition of an alkali. The colour of the stain is due to the formation of picric acid.

3. *Action on Metals.*—Gently heated in a test tube with copper filings, orange-coloured fumes are given off, which redden but do not bleach litmus paper. Starch paper treated with iodide of potassium becomes purple.

4. *Solution of Gold.*—If a small portion of gold leaf be put into the acid, no effect is produced; but on the addition of concentrated hydrochloric acid, the metal is rapidly dissolved.

II. DILUTE ACID.

1. Absence of sulphuric and hydrochloric acids, proved by no precipitate being formed with nitrate of barium and nitrate of silver.

2. It does not char paper when the paper is heated, as is the case with sulphuric and hydrochloric acids.

3. If a piece of filtering paper be dipped into a solution of the acid saturated with carbonate of potash, it will burn like touch-paper.

4. The acid liquid, saturated with carbonate of potash and evaporated, deposits *fluted* prisms which do not effloresce or deliquesce on exposure. Neutralised with soda, the crystals are of a *rhombic* form.

5. A crystal, so formed, moistened with distilled water on a plate, and then heated with strong sulphuric acid and allowed to cool, gives with—

(1) A piece of *green sulphate of iron*—a dark green ring round the crystal.

(2) A small portion of *morphia*—a rich orange colour, a yellow liquid being formed.

(3) A small portion of *brucia*—a blood-red colour.

III. MIXED WITH ORGANIC LIQUIDS, ETC.

Due to the measures employed by way of treatment the vomited matters may be neutral and yet nitric acid be present. The method adopted with viscid and turbid organic mixtures is to dilute them with pure water, and then filter. If the filtrate be acid, it is neutralised with carbonate of potash, evaporated, and then set aside to crystallise, the crystals purified by digesting them in ether or alcohol. The crystals are again dissolved and re-crystallised. The tests just mentioned should then be employed. It should be remembered that nitric acid has a strong tendency to combine with solid organic structures, and to become decomposed. The parts of the body stained by the acid should, therefore, be digested in water at a gentle heat, the liquid cooled, filtered, and neutralised with carbonate of potash, and then examined for nitre.

IV. STAINS ON THE CLOTHES, ETC.

Macerate the piece of cloth in distilled water by the aid of heat. If the solution be acid, neutralise with carbonate of potash, and filter. Test the solution as before mentioned.

The action of the dilute solution of caustic potash on the following stains on cloth is characteristic:—Nitric acid stain becomes of a clear orange tint. Iodine stain disappears. Bile stain remains unchanged.

Fatal Period—Death may take place in an hour and a half, or life may be prolonged for some months.

Fatal Dose.—Two drachms.

Treatment.—As before mentioned when speaking of the acids generally.

HYDROCHLORIC ACID.

Forms.—Strong and the dilute acid.

Characters.—*Strong hydrochloric acid* is either colourless or has a bright yellow tint, due to the presence of the perchloride of iron. It fumes in the air, and gives rise to dense white fumes when a glass rod moistened with ammonia is held over the surface of the acid. The *dilute acid* is colourless.

Symptoms.—Poisoning with muriatic acid is so rare that the symptoms have not been well studied, but they do not appear to differ much from those produced by the action of the other acids.

Chemical Analysis.—The acid will have to be examined under the following heads:—1. Simple, concentrated acid. 2. Dilute acid. 3. Mixed with organic liquids, food, etc. 4. On the clothes of the person injured.

I. CONCENTRATED ACID.

1. *Action on Organic Matter.* — The strong acid tinges most organic tissues, when immersed in it, a *yellow colour.* The stains on black cloth are at first distinctly *red*, becoming reddish-brown after a few days.

2. *Action on Metals.* — This acid does not act on copper or mercury, even when boiled with them, and this distinguishes it from the other acids.

3. Hydrochloric acid, added to peroxide of manganese and then warmed, gives off chlorine gas, detected by its greenish-yellow colour and suffocating odour. The vapour thus produced bleaches litmus paper, and causes a blue colouration on starch paper moistened with iodide of potassium.

II. DILUTE ACID.

1. Decomposes alkaline carbonates, chlorides being formed, which, when heated in the solid state with strong sulphuric acid and peroxide of manganese, evolve chlorine gas, known by the before-mentioned tests.

2. *Precipitation of Chloride of Silver.*—A white curdled precipitate of chloride of silver is thrown down when a solution of nitrate of silver is added to hydrochloric acid. This precipitate becomes grey on exposure to light. If a portion of the precipitate be added to ammonia it will dissolve ; another portion, when boiled with nitric acid, is unaffected ; and a third portion, ignited in a capsule, becomes converted into a horny mass.

In any case where there is a doubt as to whether the hydrochloric acid exists in the free state, or is only present in the form of chlorides, the following test should be resorted to, which will not only discriminate between the two forms, but give the relative amounts of each present :—

Take two equal measures of the acid liquid. Precipitate one with nitrate of silver, after the addition of

nitric acid, and weigh the precipitate. Evaporate the second portion of the acid liquid to dryness, and dry the residue in a water bath; dissolve this residue in distilled water, and treat the solution with nitrate of silver as before, weighing any precipitate which occurs. The weight of chloride of silver obtained from the first portion of the liquid will give all the hydrochloric acid present, both in the free state and in combination; while the weight of the silver precipitate in the second portion of liquid only gives the chlorides, all free—hydrochloric acid having passed off during the process of evaporation.

III. MIXED WITH ORGANIC LIQUIDS, ETC.

The suspected acid liquid should be filtered, and then distilled almost to dryness. The portion of the distillate which comes over at first may be thrown away; but the latter portion will give all the reaction before described for hydrochloric acid, if that be present. Distillation is adopted in the case of this acid, as it is more volatile than either sulphuric or nitric acid. It may be objected that the acid found in the vomited matters is from the gastric juice. In answer to this, it may be stated that the free hydrochloric acid in normal gastric juice is only about five grains in sixteen ounces, an amount which would give but slight reaction with the tests.

IV. STAINS ON THE CLOTHES, ETC.

The spots produced by the action of the acid on black cloth are at first of a *bright red* colour, changing in ten or twelve days to reddish-brown. These spots may be cut out and macerated in warm water; the liquid thus obtained then tested by nitrate of silver and the other tests before noticed. Another portion of the cloth should be treated in the same manner, and the resulting liquid tested, as a set-off against the objection that

the acid was present in the cloth. Hydrochloric acid has been used to erase writing from paper in attempts at forgery, etc. The paper must be treated in the same manner as mentioned for the cloth, and the tests used. Sometimes oxalic acid is employed for a like purpose, in which case the nitrate of silver will give a precipitate; but the oxalate of silver is soluble in nitric acid; the chloride is not soluble even when boiled.

Fatal Period.—From four or five hours to thirty hours or more,

Fatal Dose.—One ounce.

Treatment.—The same as for the other acids.

TABLE SHOWING THE COLOUR PRODUCED BY THE ACTION OF THE MINERAL ACIDS ON THE SKIN AND ON CLOTH.

	SKIN.	CLOTH.
Nitric Acid	Bright yellow, due to the formation of picric acid. Colour heightened by alkalies.	Yellow, orange-red, or brown.
Sulphuric Acid	Brown colour.	Dirty brown edges becoming red after a few days from absorption of moisture.
Hydrochloric Acid..	Greyish-white.	Bright red changing after some days to reddish-brown.

SULPHATE OF INDIGO.

A dark blue liquid formed by dissolving indigo in strong sulphuric acid. Used as a dye. The symptoms are much the same as those detailed under sulphuric acid, with the additional bluing of the mouth and lips. It may be detected with the tests given under sulphuric acid, the blue colour being first discharged by boiling it with nitric acid.

CARBOLIC ACID.

PHENIC ACID. COAL-TAR CREASOTE. OIL OF TAR.

Carbolic acid is obtained in the dry distillation of coal, and forms the acid portion of coal-tar oil, from which it is subsequently extracted by shaking the crude coal-tar oil with a mixture of slaked lime and water. After allowing the mixture to stand for some time, the watery portion is separated from the undissolved oil, the former treated with hydrochloric acid, and the resulting oily fluid purified by careful distillation.

Pure carbolic acid forms long, colourless, prismatic needles, which melt at 35° C. into an oily liquid. It boils at 180° C., and greatly resembles creasote, for which it is very frequently substituted in commerce, but from which it differs in the following characters:—It does not affect polarised light as creasote does; it forms a jelly-like mass with collodion, and is soluble in a solution of potash, whereas creasote is unaffected by collodion, and is insoluble in a solution of potash. (Specific gravity, 1·065.) It possesses a penetrating, characteristic odour; burning taste; is slightly soluble in water, but freely so in glycerine, ether, and alcohol; and gives no acid reaction to test paper. When undiluted, it attacks the skin, which it shrivels up.

Creasote is obtained from wood-tar, to which it imparts its caustic properties.

Carbolic acid acts as a corrosive and anæsthetic on the skin and mucous membranes, and as a narcotic on the brain. Its poisonous properties are equally exerted whether it be swallowed or merely applied to the skin, especially if a wound be present.

Effects on the Skin, etc.—Strong carbolic acid, when applied to the skin, corrugates, hardens, and destroys its sensibility, and is said to whiten; though, in two cases I have seen—one, where the crude acid had been

taken with a suicidal intent, there was after death a dark-browish ring about half-an-inch wide surrounding the mouth—the other, a child who, in climbing to a shelf, poured over its face and neck about half a saucerful of diluted acid. The colour of the skin touched by the acid, in the latter case, was yellowish-white and yellowish-brown, dry and parchment-like. The action of the acid on the mucous membranes is similar to that on the skin, but the corrugation is more marked, and considerable softening and peeling may also take place.

Effects on the Nervous System.—Rapidly supervening stupor, total muscular relaxation, anæsthesia, and stertorous breathing, are among the most prominent symptoms. Nearly all the sufferers die comatose. Carbolic acid appears to act principally on the central nervous ganglia at the base of the brain and on the spinal cord. The evidence is more in favour of its action on the brain than on the spinal cord, and not at all on the periphery of the nerves. The muscles contract vigorously after death, in response to galvanic stimulation applied either to the nerves or to the muscles themselves

Effects on the Circulation.—The action of carbolic acid on the circulation has not yet been fully worked out, but it appears to be a cardiac depressant, the heart being arrested in diastole.

General Symptoms.—As soon as the acid is swallowed, the patient complains of intense burning pain in the mouth, throat, and stomach, the pupils are contracted, the conjunctiva insensible to touch, the skin cold and clammy, the temperature rapidly falls, and the pulse becomes weaker and weaker, till it is almost imperceptible. The breathing is laboured, and, as the fatal issue approaches, becomes stertorous ; vomiting of frothy mucus occurs in some cases. The invasion of the symptoms is most rapid, and many of the patients have been in an insensible condition when found.

The above symptoms have even supervened when the strong acid has been used for dressing wounds.

Dr J. Hamilton records a case where the acid was used as an application to a wound four inches long, in a child four and a half years of age. Direct contact of the acid with the wound was prevented. About an hour after the dressing was applied he saw the patient. who was then supposed to be suffering from the effects of chloroform used during the operation on the child's arm. She was suffering from symptoms like those before described. On removing the dressing, some of the carbolic acid, it was found, had melted and run into the wound, and to this Dr Hamilton attributed the symptoms. The child ultimately died. (See "British Medical Journal," vol i. p. 226, 1873.)

The urine and fæces, when passed, are of a dark colour, and it has been frequently noticed that the urine passed by the assistants in surgical hospitals, who, under the present antiseptic methods adopted, are constantly washing their hands in solutions of carbolic acid, is of an olive-green colour. This shows that absorption takes place readily through the skin. Bilroth, in his work on "Clinical Surgery," gives several instances of absorption in this way.

Post-mortem Appearances.—If the poison has been drunk, a dark-brownish horny rim may be found soon after death round the lips; the mucous membrane of the mouth and stomach is whitened, corrugated, and softened, and looks as if smeared with white lead,—in some cases, horny in patches; inflammatory signs being absent or only slightly visible. The blood is uniformly fluid, becoming a bright red on exposure. The smell of carbolic acid is detected in the stomach, and sometimes in the small intestine, and even in the spleen, liver, and kidneys. In Dr Ferrier's case, the urine found in the bladder after death had a slight olive-greenish tint with a peculiar mixed odour, which gave the usual reactions to the tests for carbolic acid. The

dark colour of the urine is not due to the presence of hæmin, as the urine, in poisoning by carbolic acid, does not contain more than a normal amount of iron; the colour is, therefore, probably due to some product formed by the partial oxidation of the acid. The left ventricle of the heart is, in most cases, found contracted, the right flaccid. The lungs are congested, and this may also be the case with the vessels of the brain; but there may be an entire absence of any *post-mortem signs* to point to the probable cause of death, where the poison has gained entrance through a wound when the acid has been used as a surgical dressing.

Chemical Analysis.—Bromine water, as recommended by Landolt, gives a bulky yellowish precipitate of tri-bromo-phenol. The precipitate should then be collected, well washed, and gently warmed in a test tube with sodium-amalgam and water. The liquid poured into a dish and acidulated, will, if phenol be present, give the characteristic odour of that substance, and may be seen floating in the liquid as an oily fluid. By this test, one part of phenol in 43,700 of water may be detected. It must be remembered that, according to Landolt, carbolic acid is normally present in the urine, but Hoppe Seyler contends that it is not originally present in urine, but is formed by the action of sulphuric acid, probably from indican. Carbolic acid urine, treated with nitric acid, and then with potassa, and concentrated, becomes blood-red, brown-red, and then changes from pea-green to violet. Carbolic acid mixed with urine does not give the above reactions (Schmidt's "Jahrbucher," bd. clxiv., page 144).

A solution of carbolic acid, mixed with one-fourth of its volume of ammonia and a few drops of bleaching-powder solution (1 in 20 of water), and then warmed, but not boiled, assumes a blue colour (green in very dilute solutions), becoming red on the addition of sulphuric or hydrochloric acid. The perchloride of iron gives a blue colour with carbolic acid.

Fatal Period.—One hour or more.

Fatal Dose.—An ounce, probably less.

Treatment.—Stomach pump, and the administration of oil and demulcent drinks. Emetics are of little or no use, owing to the anæsthesia of the mucous membrane of the stomach. The sulphate of soda, Glauber salts, has been proposed as an antidote. Any soluble sulphate may be tried. Oil is the best outward application to the skin.

OXALIC ACID.

This is a powerful corrosive and cardiac poison, but on account of its strongly acid taste it is ill-adapted for the purposes of the murderer. Deaths have not infrequently followed the accidental substitution of this substance for Epsom salts — sulphate of magnesia — which it somewhat closely resembles.

The ordinary crystals of oxalic acid are in the form of four-sided prisms, colourless, transparent, odourless, or with a slight acid smell, very acid taste, and not deliquescent in the air. It is largely used in the arts, by brass-polishers, straw-bonnet makers, bookbinders, and others. The acid is also used to remove writing-ink from parchment, paper, etc., for the purposes of forgery, etc.

Symptoms.—These present many strange anomalies. In a large dose—an ounce or more—oxalic acid acts as a corrosive; in a smaller, as an irritant; and in a still smaller dose, as a cardiac sedative. Death has been known to occur so rapidly as to prevent any attempt at treatment. When the dose is large, an acid taste is experienced during swallowing, followed by burning pain in the throat and stomach. Vomiting then sets in, and in most cases continues till death, which may, however, occur when this symptom has existed from the first. The vomited matters may be simply mucus, mucus and blood, or dark coffee-grounds-looking matter.

Unless the case is protracted, the bowels are rarely much affected, though purging and tenesmus have been noticed. Collapse now sets in; the pulse becomes feeble and scarcely perceptible, the skin cold and clammy, showing the action of the poison on the heart probably through the central nervous, as well as through the intra-cardiac, ganglia. Should the treatment adopted prove successful, and life be prolonged, the patient complains of tenderness of the mouth, soreness of the throat, and painful deglutition. Pressure over the abdomen causes pain. Vomiting and purging are also frequently present; and if recovery takes place, convalescence is generally very gradual.

Oxalic acid acts as a poison when applied to a wound in any part of the body; and although this substance undoubtedly acts on the brain through the medium of the blood, it is a remarkable fact that *it cannot be detected in that fluid*, even when injected into the femoral vein of an animal which died in thirty seconds (Christison). Leeches, it is recorded, have been poisoned by the blood drawn by them from persons suffering from oxalic acid poisoning. The blood does not appear to undergo any physical change. Unlike the mineral acids, oxalic acid is still poisonous even when its corrosive and irritant properties have been destroyed by dilution.

Post-mortem Appearances.—The mucous membrane of the mouth, tongue, and throat is corrugated, white, and softened. The tongue is sometimes of a brownish colour, and sordes appear on the teeth. The stomach is in some cases pale, soft, and very brittle, and contains a dark, grumous, acid liquid; at other times it presents several semi-gelatinous spots, looking as if they had been boiled. Enlarged blood-vessels filled with dark-coloured blood are also seen ramifying over the internal surface of the organ. Perforation is of

rare occurrence. The intestines generally escape with some slight inflammatory redness, unless the case is unusually prolonged. In some cases the stomach is quite healthy, no morbid appearance being found in any portion of the alimentary canal.

Chemical Analysis.—From organic mixtures the acid may be separated by dialysis, and the tests applied, or it may be obtained in crystals by precipitating it from the boiled and filtered organic mixture with acetate of lead. The precipitate washed is then decomposed by sulphuretted hydrogen and filtered, the filtrate concentrated to drive off excess of sulphuretted hydrogen, and then set aside to crystallise, which, if the acid be present, it does in slender prisms. Should, owing to the treatment adopted, oxalate of lime in white chalky masses be found in the stomach, these should be washed and then boiled with pure carbonate of potash. A partial decomposition takes place, insoluble carbonate of lime and soluble oxalate of potash are present in the liquid, which, when filtered and neutralised with nitric acid, may be tested with the following reagents :—

1. *Nitrate of silver* gives a white precipitate, *soluble* in *cold* nitric acid; the precipitate dried and heated on platinum foil is dissipated in a white vapour with slight detonation.

2. *Sulphate of lime* produces a white precipitate immediately dissolved by hydrochloric or nitric acid, but not dissolved by oxalic, tartaric, acetic, or other vegetable acid. Lime water should not be used as a test, as it gives precipitates with other acids; the sulphate largely diluted is not open to this objection.

On clothes, parchment, etc., the spot or spots must be well boiled, and the above tests applied to the solution. The stains may vary from a brownish-red to orange-red colour.

Fatal Dose.—Three drachms have caused death in one hour; but recoveries have been known to take place after an ounce had been swallowed.

Fatal Period.—Death has resulted in *ten minutes* from a dose of *one ounce.* The time varies with individuals, even when the same quantity is taken. In the case of two girls who each swallowed *an ounce* of oxalic acid, one died in *ten minutes* and the other in *thirty minutes.*

Treatment.—Water should not be given, as it increases the solubility of the acid, and thus assists in the more extensive absorption and diffusion of the poison. The carbonates of potash and soda should be avoided, as the oxalates of these alkalies *are themselves* poisonous. Lime is the best antidote, as the oxalate of lime is insoluble. Vomiting should be promoted. In the stage of collapse the case must be treated on general principles.

ESSENTIAL SALT OF LEMONS.

The binoxalate of potash or salt of sorrel, or, as it is more commonly known as salt of lemons, occurs as a constituent of many plants. The common sorrel—*Rumex lacetosa*—contains it in large quantities.

Symptoms.—Those of poisoning by oxalic acid, on which its poisonous properties depend.

Post-mortem Appearances. — Inflammation of the stomach and intestines. Other appearances as in oxalic acid.

Chemical Analysis.—See Oxalic Acid.

Fatal Period—Eight minutes in the case of a lady recently confined, who took half-an-ounce of the salt by mistake for cream-of-tartar.

Fatal Dose.—Half-an-ounce.

Treatment.—The same as recommended for poisoning by oxalic acid.

TABLE SHOWING SYMPTOMS, POST-MORTEM APPEARANCES, FATAL DOSE, PERIOD OF DEATH, AND TREATMENT OF POISONING BY

	SULPHURIC ACID.	HYDROCYANIC ACID.	OXALIC ACID.
Symptoms	Burning pain in the mouth, throat, and gullet. Constant vomiting of brownish or blackish matter containing blood. The lips shrivelled, blistered, and excoriated; and the corners of the mouth shows signs of the corrosive action of the poison. Collapse and death.	Giddiness, insensibility, difficult respiration, dilated pupil, tetanic spasms, and convulsions. In acute cases, death by shock; in those more prolonged, suffocation ends the scene.	Burning pain in the mouth and throat, vomiting of greenish-brown or grumous matter. Collapse sets in; skin cold and clammy; frequent pulse, and respiration hurried. Delirium and convulsions end in death. Effects depend on size of dose. Well diluted, it acts on brain, spine, and heart.
Post-mortem Appearances	Presence of the signs of powerful corrosion; perforation of the stomach, which is blackened and softened.	Face pale and countenance composed; congestion of the brain, and traces of inflammation in the stomach and bowels. Odour of prussic acid may be detected in most cases in the stomach and other parts of the body.	Lining membrane of mouth and fauces white, shrivelled, and easily removed. Perforation of stomach rare. The *post-mortem* appearances depend on dilution of acid.
Fatal Dose	One drachm.	About 45 minims of the Pharmacopœia acid.	One drachm in a boy; in another case, half an ounce.
Fatal Period	One hour. Average about ten hours.	Two to five minutes.	Less than ten minutes.
Treatment	Magnesia, chalk, whiting, soap suds, milk, and mucilaginous drinks.	Chlorine in vapour and in water, and the mixed oxides of iron. Cold affusion to the head and face, galvanism, artificial respiration, etc.	Chalk and water. Promote vomiting, Magnesia, lime water, and oil. Mucilaginous drinks.

THE ALKALIES.

POTASH. SODA. AMMONIA.

Poisoning by the use of the alkalies is very rare. For the sake of convenience, and as the symptoms produced by the caustic preparations of soda and potash, taken in large doses, do not greatly differ, one description will do for both :—

Potash is found in commerce as — (1) Caustic potash, either solid or in solution. (2) Carbonate and bicarbonate. (3) Pearl-ash and soap-lees.

Soda is found as — (1) Caustic soda. (2) Carbonate and bicarbonate. (3) Soap-lees, carbonate of soda mixed with caustic alkali.

General Characters.—Like the inorganic acids, the alkalies destroy the animal tissues with which they come in contact. Their action is local, no specific remote effects being produced. They are seldom, if ever, used for the purpose of homicide ; the deaths caused by them are in most cases the result of accident or suicide. When injected directly into the veins of animals, the toxic action of potash and soda appears to differ, the former arresting the action of the heart in diastole, whereas the latter, according to Podocaepow and Guttman, does not, even in large doses, affect the heart or temperature—Guttman, moreover, asserting that soda has no influence upon the nerve centres, the peripheral nerves, or the muscles. It is difficult to understand how, with this asserted negative action, soda, like potash, causes death.

Symptoms. — During the act of swallowing, the patient complains of a caustic taste, accompanied with a sensation of burning in the mouth and throat, extending into the stomach. Vomiting may or may not be present ; but in severe cases, when it does occur,

the vomited matters may be mixed with blood. The surface of the body is cold, and bathed in a cold sweat. Purging is generally present, accompanied with intense pain and straining. The pulse is weak and quick, and the countenance anxious.

The *Post-mortem* appearances are inflammation and softening of the mucus membrane of the mouth, gullet, and stomach, which may also be covered with chocolate or black-coloured spots. Where life has been prolonged for some months the stomach may become contracted, the pyloric orifice scarcely admitting the passage of a fine probe.

Chemical Analysis.—The caustic alkalies are known from their carbonates, by giving a brown precipitate with nitrate of silver; whereas their carbonates give a white, and also effervesce on the addition of an acid.

The following Table will show the reaction of these alkalies with reagents:—

TO DISTINGUISH CAUSTIC POTASH FROM CAUSTIC SODA.

	POTASH.	SODA.
Bichloride of Platinum.	A canary-coloured precipitate in solutions acidulated with hydrochloric Acid.	No precipitate.
Strong Solution of Tartaric Acid.	Precipitate in granular white crystals.	No precipitate.
Colour given to Flame.	Rose or lilac tint.	Yellow tint.
Neutralised with Nitric Acid.	Crystallises in long, slender, fluted prisms.	Crystallises in rhombic plates.

In Organic Mixtures.—If the mixture be strongly alkaline, filter and test as above.

Fatal Period.—From three hours to as many years.

Fatal Dose.—About half-an-ounce of the caustic alkali.

Treatment.—Water freely; drinks containing citric or acetic acid, vinegar, lemon juice, oil, linseed tea, and other demulcent drinks.

AMMONIA.

In vapour, in solution, or solid.

Symptoms.—The vapour may cause death by producing inflammation of the larynx and lungs. The symptoms to which it gives rise are a feeling of choking, and a suspension of the power of breathing. Intense heat and pain are felt in the throat, which may remain for some time. When ammonia is swallowed in solution, the symptoms produced are not unlike those the result of the action of soda or potash, only more intense. Dr Patterson records the history of a case of a poor man who drank about an ounce of the liquid ammonia. When seen, his lips were livid, breathing stridulous, aspect anxious, extremities cold, pulse 100; inside of mouth, tongue, fauces, as far as visible, red, raw, and fiery-looking. He died suddenly, nineteen days after the accident, of laryngismus stridulus.

The *post-mortem* appearances are those found in most cases of poisoning by corrosives.

Chemical Analysis.—The vapour of ammonia is easily set free and recognised by its pungent odour. The carbonate effervesces when an acid is added to it, and gives a white precipitate with salts of lime.

Fatal Period.—Death has been known to occur in *four minutes*, but life may be prolonged for some time, the person dying of some thoracic trouble.

Fatal Dose.—A tea-spoonful of the strong solution.

Treatment.—Vinegar and water, lime-juice and oil, and leeches to the throat if the inflammatory symptoms be severe. The rest of the treatment will depend upon the symptoms present.

CAUSTIC SALTS.

CHLORIDE OF ANTIMONY. CHLORIDE OF ZINC.
CHLORIDES OF TIN. NITRATE OF SILVER.

CHLORIDE OF ANTIMONY.

Chloride of antimony (butter of antimony) is a corrosive liquid. The colour varies from a light yellow to a dark red. Though a powerful poison, it is seldom taken for that purpose. It has been taken by mistake for ginger beer. On the addition of water, the white oxychloride is precipitated.

Symptoms.—The symptoms produced by swallowing this substance are those of corrosive poisoning. The mouth and throat are excoriated, the skin cold and clammy, and the pulse feeble and quick. Severe pain is felt in the stomach, and vomiting is incessant.

Post-mortem Appearances.—Those found after corrosive poisoning.

Chemical Analysis.—When poured into water, the chloride is precipitated; the precipitate, soluble in tartaric acid, becomes orange-red on the addition of hydrogen sulphide. The supernatant liquid will give a white precipitate with nitrate of silver, showing the presence of hydrochloric acid. The salts of bismuth are precipitated by the addition of water, but the precipitate is, unlike the antimonial, insoluble in tartaric acid, and is blackened by hydrogen sulphide.

From *organic* liquids, the antimony may be obtained by boiling them with tartaric acid, filtering, and then applying the tests for antimony.

Treatment.—Milk, magnesia, and infusions containing tannin.

CHLORIDE OF ZINC.

This substance is a powerful corrosive. It is employed as a disinfectant, and is sold to the public under the name of "Sir W. Burnett's Fluid." This preparation, which is a strong solution of the chloride of zinc, has caused death by being mistaken for "fluid magnesia," for "pale ale," and in one case, on board one of the American steamers, for "mineral water." Chloride of zinc is also used in the treatment of cancer and other tumours as an external application.

Symptoms.—The symptoms come on immediately after the poison is swallowed. Chloride of zinc acts as a powerful corrosive, accompanied with all the symptoms which have been before described when speaking under the head of corrosive poisons. The nervous system is also powerfully affected.

Post-mortem Appearances. — Those of corrosive poisoning in its most violent form. The mouth, throat, stomach, and intestines are often found hardened, white, opaque, and corrugated.

Chemical Analysis.—Ammonium sulphide gives a white precipate, which is insoluble in caustic alkalies. Hydrogen sulphide gives a white precipitate in neutral solutions, but no precipitate when the free mineral acids are present. Potassium ferro-cyanide gives a white precipitate. Test for chlorine with nitrate of silver.

Treatment.—White of eggs, emetics, followed by demulcent drinks.

CHLORIDES OF TIN.

This metal requires but little notice; but the two chlorides—protochloride and the perchloride—form a mixture used in the arts, and known as *Dyer's Mixture.* They act as irritant poisons, but are seldom used as such.

NITRATE OF SILVER.

The only preparation of silver requiring notice is the nitrate—*lunar caustic*, or *lapis infernalis*. It acts as a powerful corrosive. If administered for some time in small doses, it is deposited in the skin which acquires a permanent dark colour. It does not appear to be eliminated by the urine, and has been discovered in the liver five months after its administration was discontinued.

The symptoms come on immediately; the vomited matters becoming blackened on exposure to light. The dark spots on the skin will also help to point to the nature of the poison. A dose of salt and water may be given by way of treatment.

VULNERANT.

GLASS, ENAMEL, AND NEEDLES.

None of the above can be considered as poisons; but should they be taken, they give rise in most cases to irritation of the stomach and bowels. Pins and needles have been swallowed without doing much harm. Mixing ground glass in food is a favourite mode of killing adopted by the West Indian negroes.

VITAL.

METALLOID IRRITANTS.

PHOSPHORUS. IODINE.

PHOSPHORUS.

Poisoning by this substance is more common in France than in England. In England, the deaths due to this poison are more frequently the result of accident, from the incautious use of phosphorus paste for

the destruction of vermin. Children have also been poisoned by sucking the heads of Lucifer matches. In one case, that of a child, death followed from sucking about forty matches. It has most frequently been employed as a means of suicide, but seldom for the purpose of homicide. One case, however, occurred at the Bodmin Assizes in 1857. Kopf relates a case of a young woman, aged twenty-four, who died on the fourth day after swallowing the heads of six packets of Lucifers. ("*Allg. Wien. Med. Ztg.*," No. 47, 1819; Schmidt, vol. cv., page 296.) The size of the packets is not stated. In this case the bowels were confined, and the *post-mortem* revealed only the redness of inflammation in the stomach and bowels.

General Characters.—There are two kinds—ordinary waxy, crystalline phosphorus, and a peculiar form known as allotropic or amorphous phosphorus, prepared by heating waxy phosphorus to a temperature of 240° C., in an atmosphere free from oxygen. As found in the shops, phosphorus is preserved in water in the form of translucent white or slightly yellow-coloured cylinders. It is sparingly soluble in oil, alcohol, and other hydro-carbons, but greatly so in bisulphide of carbon. White vapours are given off when it is exposed to the air, these consisting of phosphorous and phosphoric acids.

Symptoms.—Phosphorus acts as an irritant poison, but some days may elapse after the poison is taken before the injurious effects become apparent. The patient may then complain of a garlic-like taste in the mouth, peculiar to poisoning by this substance. This is followed by a burning sensation in the throat, accompanied with severe pain in the stomach, and intense thirst. The belly becomes swollen, and there is vomiting, in some cases, of blood from the stomach, which may continue till death. The vomited matters are of a dark-green or black colour, with an odour of garlic,

and sometimes appearing phosphorescent in the dark. This condition may also be observed in the motions passed. The pulse is feeble, the countenance anxious, and the surface of the body bathed in a cold sweat. In males, priapism is not infrequent. The nervous and muscular debility is intense, and the patient may die in a state of collapse or during a fit of convulsions. Purpuric spots may appear on the skin, due to the altered condition of the blood. The liver shares in the general disorder, and jaundice, more or less intense, not infrequently occurs. It is by no means always easy to diagnose acute yellow atrophy of the liver or malignant jaundice from phosphorus poisoning. In phosphorus poisoning, the early symptoms, those of acute gastritis, are more severe, are developed more rapidly, and run their course more quickly than in acute atrophy, and there is a marked interval between these and the appearance of the jaundice ; in acute yellow atrophy this interval is wanting, and from the beginning, on the contrary, there are gradual malaise, slight gastric catarrh, and jaundice. The jaundice and suffering, together with the increased action of the heart in phosphorus poisoning, is wanting in malignant jaundice, but the cerebral symptoms are more marked in the latter than in the former. Acute yellow atrophy most frequently occurs in women, especially during pregnancy.

Chronic poisoning, accompanied with all the symptoms just mentioned, may result from the action of the vapour on those engaged in the manufacture of phosphorous or of Lucifer matches. In persons thus employed, necrosis of the jaws and caries of the teeth are not of infrequent occurrence. Mr Lyons states that this form of necrosis cannot attack persons who have perfectly sound teeth, but only those whose teeth are carious. (St Bartholomew's Hospital Report," vol. xii.)

Post-mortem Appearances.—Those of acute irritant poisoning, including extensive destruction of the coats

of the stomach, by softening, ulceration, and perforation, terminating in gangrene. The stomach may contain a quantity of white vapour, having a strong smell of garlic. This white vapour has been noticed to pass from the vagina and anus of those poisoned by phosphorus. The blood appears to be thoroughly disorganised; the blood-cells are colourless and transparent, their colouring matter being dissolved in the uncoagulated liquor sanguinis. In a case recorded in the "British Medical Journal," 1873, fatty degeneration of the liver and kidneys was found a week after the poison was taken. In phosphorus poisoning, the liver is enlarged, of a dull appearance, doughy, uniformly yellow, with the acini well marked; in acute atrophy, the liver is diminished in size, greasy on the surface, leathery, of a dirty yellow colour, with traces only of the obliterated acini. In the former, also, the hepatic cells are either filled with oil globules or entirely replaced by them; in the latter, the cells are filled with a fine granular detritus, and their structure replaced by newly-formed connective tissue. Putrefaction rapidly supervenes on death.

Chemical Analysis.—The smell of phosphorus is characteristic, as is also its luminosity when exposed in the dark. The following process, suggested by Mitscherlich, may be adopted for its detection:—

To render the suspected matter quite fluid water is added, previously acidulated with sulphuric acid, in order to neutralise any ammonia present. The liquid is then transferred to a glass retort, fitted with a long condensing tube passing into a receiver. Distillation is conducted in the dark, when the minutest trace of phosphorus may be detected by the luminous appearance of the vapour during condensation. Other modifications of this process have been suggested, in order to increase the space occupied by the phosphorescence.

By the above process, one part of phosphorus may be detected in 100,000 parts of substance. Another method for the detection of this poison in very minute quantities is that proposed by Dusart ("Compt. Rend." xliii., 1126), and modified by Blondlot ("Compt. Rend." lii., 1197). The test is based on the fact that when phosphorus is exposed to the action of *nascent hydrogen* in a Marsh's apparatus, it burns with an emerald-green flame. In order to avoid the yellow colouring of the flame produced by the sodium in glass, Blondlot recommends the use of a platinum jet. As the green colour is more or less interfered with by the presence of organic matters, he passes the gas through a solution of nitrate of silver; the resulting precipitate is then placed in another hydrogen apparatus, as just mentioned, and the colour of the flame of the issuing gas noted. Phosphorus may become decomposed in the body; and as phosphoric acid is taken in most articles of food, the only satisfactory evidence of phosphorus having been taken is to produce it in its free state, or at least to exhibit its luminosity. The detection of the colouring matter of Lucifer matches in the stomach or vomited matters will point to the probable nature of the poison, and whence it was derived.

Fatal Period.—From four hours to twenty days or more.

Fatal Dose.—One grain and a half.

Treatment.—Emetics, especially the sulphate of copper well diluted in three-grain doses at short intervals, the use of the stomach pump, and the administration of demulcent drinks in which the hydrate of magnesia is suspended, will form the best mode of treatment. Sulphate of copper has been proposed as an antidote, as with phosphorus it forms a black phosphide (Bamberger). Oil should not be given, as phosphorus is soluble in it. Turpentine was first suggested by Andant as an antidote, an emetic having been previously administered.

According to some observers, turpentine is said to be of no value; but this failure in the use of turpentine has been shown to be due to the employment of different varieties of oil. The crude acid French oil, of the three kinds met with in commerce, appears to be the only one that acts as described below. With turpentine, phosphorus forms a spermaceti-like mass consisting of *turpentine phosphorous acid.* It has an acid reaction, and is converted, on exposure to the air into a resinous substance, smelling like pine-rosin. With earths and metallic oxides it forms insoluble salts. The acid is not poisonous; doses of 0·03 to 0·3 gram. may be given to dogs and rabbits without any other effect than that of lowering of the bodily temperature. To the formation of this compound, the antidotal properties of turpentine in phosphorus poisoning are attributed. ("*Kohler a. Schempf Dingl.*," pol., Jcxcix.)

Synopsis of the Effects due to Poisoning by Phosphorus.

1. Which variety of phosphorus is poisonous?—The ordinary yellow phosphorus usually kept in water. The allotropic form is inert.

2. What quantity is sufficient to kill an adult?—One grain and a half.

3. Symptoms as regards—

(1) *Alimentary Canal.*—Pain in the stomach and belly, eructations of gas smelling like garlic, vomiting, and sometimes purging, with other signs of irritation.

(2) *Circulatory System.*—Tendency to hæmorrhage from the mouth, stomach, lungs, bladder, etc. Petechiæ and ecchymoses may occur on all parts of the body. If the case be prolonged, anæmia may be present. Pulse small, weak, and scarcely perceptible.

(3) *Nervous System.*—Cramps, creeping sensations in the limbs, delirium, convulsions, paralysis, and extreme nervous prostration.

(4) *Period of Invasion of the Symptoms.*—Obscure and insidious; some hours or even days may elapse before the appearance of the symptoms.

(5) *Period of Fatal Termination.*—In some cases as short as four hours.

4. *Post-mortem* Appearances—

(1) *Alimentary Canal.*—Signs of irritation and inflammation in the stomach and intestines. Gangrene and perforation have been noticed. Strong smell of garlic when the abdomen is laid open. Appearances not unlike scurvy may be found.

(2) *Cellular Tissue.*—Ecchymosis may be present in the cellular tissue of the abdomen, chest, and other parts of the body.

(3) *Muscular Tissue.*—Fatty degeneration in the heart and other organs of the body has been noticed in several cases.

(4) *Liver.*—Fatty degeneration of the gland.

(5) Blood entirely disorganised, the cells transparent, and their contents dissolved in the uncoagulated liquor sanguinis. The colour, cherry-red.

5. *Name* special affection produced by phosphorus in Lucifer match makers—Necrosis of the jaws, usually of the lower jaw. The disease begins in a decayed tooth.

6. *Name* a natural disease which phosphorus poisoning has been supposed to resemble.—Acute yellow atrophy of the liver.

IODINE.

Iodine is seldom used as a poison, owing to the difficulty experienced in disguising its colour. In the form of a strong solution it has been, however, employed for throwing on the person with intent to cause grievous bodily harm, as in this form it is corrosive, and destroys the part which it touches.

General Characters.—Iodine is a dark grey solid, with a bright metallic lustre. It melts at 107°, boils at 175°, and gives off at the ordinary temperature a faint odour not unlike chlorine. But slightly soluble in pure water, it is, however, readily dissolved when a soluble iodide is added to the water.

Symptoms.—These produced by irritant poisons generally; the severity of the symptoms being increased by the strength of the solution, iodine possessing corrosive as well as irritant properties.

Post-mortem Appearances.—Those the result of acute irritant poisoning.

Fatal Period.—Two days.

Fatal Dose.—One drachm or less.

Treatment.—The stomach should be emptied by the aid of the stomach pump, and then diluent drinks—arrowroot and barley water—may be given.

Chemical Analysis.—Add bisulphide of carbon to the suspected mixture, and shake them together. The sulphide will dissolve out the iodine, which may be obtained on evaporation and sublimed. The characteristic reaction of iodine, the development of a blue colour on the addition of a small quantity of starch, will be conclusive evidence of its presence.

IODIDE OF POTASSIUM.

This salt is largely used in medicine; and though poisonous effects may be produced, due probably to some constitutional idiosyncrasy, it has seldom been used as a poison. It must, however, be placed among noxious irritant substances.

General Characters.—Iodide of potassium—hydriodate of potash—occurs in cubical crystals of a white or faint yellow colour, very slightly deliquescent when pure, and with a feeble odour of iodine.

Symptoms.—Iodide of potassium acts as an irritant in large doses, producing also many of the symptoms which attend a violent catarrh. Small doses—three to five grains—have produced in some persons most unpleasant and even alarming symptoms. In chronic poisoning, certain glands, the mammary and testicles, are said to waste away. Salivation is not infrequently present. (See the account in "British Medical Journal," 1878, of a case of purpura in a child five months old, after a dose of two and a half grains of the salt.

Treatment.—The use of emetics and the stomach pump, starch, etc.

Chemical Analysis.—In solution, iodide of potash gives the following characteristic reactions:—

1. With a salt of lead, . .	Bright yellow precipitate.
2. With corrosive sublimate, .	Bright scarlet precipitate.
3. With strong nitric acid and starch,	A blue colour.

In organic mixtures the mode of detecting it is more complicated.

Sulphuretted hydrogen should be first passed through the mixture in order to convert any free iodine into hydriodic acid. The excess of the gas is then driven off by the application of heat, and potash added, the resulting liquor filtered, and the filtrate evaporated to dryness. To get rid of any organic matter, the residue left after evaporation is charred at a low red heat, reduced to powder, and dissolved in water. This solution is then concentrated, and strong nitric acid and solution of starch added, when, if iodine be present, the blue colour will be developed.

METALLIC IRRITANTS.

ARSENIC.

Arsenic is found as metallic arsenic, as arsenious acid, in the form of two sulphides—realgar and orpiment, and as a constituent of several ores — iron, copper, etc.

Metallic arsenic is of a steel grey colour, brittle, and sublimes at a temperature a little below 400° F., without, however, previously fusing. The vapour of the metal has a peculiar garlic-like odour, which is not possessed by any of its compounds.

Arsenious Acid.

Arsenious acid — white arsenic, — the most important of all the compounds of arsenic, is colourless,

odourless, and almost devoid of taste. As found in commerce, it occurs under two forms—as a white powder, and as a solid cake, which is at first nearly transparent, but soon becomes opaque, and then resembles white enamel. At a temperature of about 380° F. it sublimes, but is again deposited on cool surfaces in the form of octahedral crystals. It is but slightly soluble in cold water, only about half a grain to a grain being taken np by an ounce of water. Stirred in boiling water, and then allowed to cool, from a grain to a grain and a quarter is dissolved in the same quantity of water; but when it is boiled for an hour, about twelve grains are dissolved in the ounce of water. This solubility is, however, diminished by the presence of any organic matter in the liquid. It is therefore less soluble in infusions of tea or coffee than in pure water. A teaspoonful of powdered arsenic is said to weigh 150 grains, and a pinch, 17 grains.

Arsenious acid is used in the arts in the manufacture of certain green colours, in dyeing, and in calico printing. A weak solution is employed in medicine; in the treatment of certain diseases of the skin, in ague, and in other diseases.

It has been proposed to use arsenious acid, on account of its caustic properties, as an application for cancerous tumours. The employment of this substance for this purpose is by no means new; but its use has been revived from time to time by the charlatan. In the year 1844, a man was tried at the Chester Winter Assizes (R. *v.* Port) for the murder of a woman whom he pretended to cure of a cancer by the use of an arsenical plaster. In another case, recorded by M. Flandin, where death occurred, the quack declared that he had not applied more than *four* or *five* grains to the woman's breast. The powder used by these gentlemen is generally composed of arsenious acid, realgar, and oxide of iron. The above cases, to which

many more might be added, attest to the danger which attends the application of arsenic to the surface of the body; it should, therefore, never be used, especially as a more safe and potent caustic for this purpose is found in the chloride of zinc. Some years ago, in London, several cases of severe arsenical poisoning were due to the presence of arsenic in some cheap violet powder. In one case I attended, the navel and scrotum of a baby were fearfully excoriated, due to the use of this powder.

Farmers employ arsenious acid (white arsenic) for destroying vermin: for steeping corn in order to destroy any spores of fungi; and it also forms an ingredient in the wash for sheep. Injurious effects have followed the accidental use of the corn thus treated, and those employed in washing the sheep have suffered more or less severely.

By an Act of Parliament (14 Vict., cap. xiii., sec. 3), it is ordered that if sold in small quantities, it must be mixed with the sixteenth part of its weight of soot, or the thirty-second part of its weight of indigo, ten pounds being the smallest quantity allowed to be sold unmixed.

The presence of this admixture must be remembered, as a medical man may be led into an error when the vomited matters are coloured blue, black, or green, from the mixture of bile with the indigo. Arsenic is not, as a rule, a corrosive poison, nor does it act chemically on the animal tissues. One case is, however, on record where it acted as a corrosive, but the purity of the arsenic in that case has been questioned. Its action is that of an irritant causing inflammation in the stomach and bowels of those who have taken it; and it appears that fatal effects are produced whether the poison be swallowed or introduced into the system in any other way—*i.e.*, by injection into the rectum or vagina, or applied to the surface of the body.

Arsenic cannot be considered in the light of an accumulative poison. Given in medicinal doses, it is eliminated in from fifteen to twenty days. Hence, in cases which have survived the immediate action of the drug, no arsenic may be found in the body fifteen days after its fatal administration. This is a fact of considerable importance. In the case of Pierre Emile L'Angelier, for whose murder Madeline Smith was tried, Dr Penny found 88 grains in the stomach, although the deceased survived eight or ten hours after the probable period of taking the poison, and vomited repeatedly during that time. At the above trial, the question was suddenly started, that if such a large quantity was found after death in the stomach, it was scarcely possible to infer the administration of a much larger quantity; and thus that the quantity must have been larger than another party could have secretly administered, or naturally would attempt to administer. Drs. Mackinlay and Wylie, of Paisley obtained 60 grains, and Sir R. Christison 30 grains more, from the stomach of a man poisoned by arsenic administered in whisky-punch sweetened, and the arsenic kept in suspension by constant stirring.

Symptoms of Arsenical Poisoning—

Acute.—The rapidity and virulence of the symptoms are more or less modified by the form (*i.e.*, solution) and the quantity of the dose taken. From half-an-hour to an hour is the usual time which elapses before the symptoms of poisoning present themselves. In one case, when the poison was in solution, the symptoms came on immediately after it was swallowed; in another, after the lapse of ten hours. The patient first complains of a feeling of faintness and depression, followed with intense burning pain in the stomach, increased by the slightest pressure. Nausea and vomiting, the latter increased by the act of swallowing,

now occur. The vomited matters may be dark-brown, black or bilious; or they may be greenish from the indigo mixed with the arsenic coming in contact with the yellow colouring matter of the bile. Blood may also be vomited. Purging, accompanied with straining at stool, and cramps in the calves of the legs may occur; the purging, like the vomiting, being incessant, and affording no relief to the sufferer. The thirst is intense, the pulse feeble and irregular, and the skin cold and clammy. The urine may or may not be suppressed. As a rule, the symptoms in this form of poisoning are *continuous;* but cases occur in which there are distinct *remissions*, and even *intermissions.* Coma, paralysis, or tetanic convulsions, may supervene before death closes the scene.

Certain anomalies may occur.—The pain may be absent or but slight. Vomiting and purging do not occur in all cases, nor is thirst, a most common and persistent symptom always present. In some cases the symptoms resemble those which accompany an attack of cholera. In others, signs of collapse first make their appearance, from which the patient may rally, or he may die outright. These variations in the symptoms do not appear to be due to the *form* or *quantity* of the poison taken. It should also be remembered that arsenic may produce symptoms closely resembling those the result of *narcotic poisoning.*

Chronic.—The symptoms are not so well pronounced as in acute poisoning. The eyes become inflamed and watery. The skin may be irritable, and in some cases patches of a vesicular eruption ("eczema arsenicale") appear. Dr Prosper de Pietra Santa describes a disease to which workers in manufactories of paper coloured with Schweinfurt-green are liable, characterised by the appearance of vesicles, pustules, "*plaques muquenses,*" and ulcerations on the exposed part of the body, fingers, toes, and scrotum. Arsenical poisoning has been

mistaken for nettle-rash and scarlet fever. Paralysis, more or less general, is not of infrequent occurrence. The sufferer emaciates, the hair falls off, and he dies from exhaustion. The tongue in some cases is excoriated, and salivation is also present, fœtor of the breath being well marked. Jaundice has also been noticed in some cases. The symptoms of this form of poisoning are frequently so misleading, that death due to the action of arsenic has been referred to "spontaneous inflammation of the bowels.

Post-mortem Appearances.—The appearances found after death depend upon the quantity of the dose and the length of time which supervenes between the taking of the poison and death. Inflammation of the stomach is a marked effect of the action of this substance on the system; and this condition is in most cases present whether the poison be swallowed, sprinkled on an ulcerated surface, or rubbed into the skin. The inflammatory redness, which may assume the appearance of *crimson velvet*, may be found in cases where death has taken place in *two* hours. It is sometimes found spreading over the entire surface of the stomach; at others, at the cardiac end only. The red colour is increased on exposing the stomach to the air. When the poison has been swallowed, the stomach may be found covered with white patches of arsenic, embedded in dark-coloured thick mucus, mixed with blood. Dr Paterson thus describes the condition of a stomach he examined:—Its lining membrane was generally very red and injected; but in addition there were very numerous stellated patches of vivid red, leading to a darker tint; in the centre of some of them was noticed a minute clot of blood; in others, an exceedingly rough particle of a crystalline substance, which was afterwards found to be arsenious acid. Perforation of the stomach is extremely rare, if it has ever occurred, but ulceration of the same organ has

been observed in a person who died from the effects of arsenic in *five* hours. (Christison, on "Poisons," page 340.) In opposition to all the statements just made it has been shown that arsenic may prove fatal without leaving any inflammatory sign of its action. (R. *v.* M'Cracken : R. *v.* Newton.)

The mouth, pharynx, and gullet are generally found free from any inflammatory action. The small intestines may or may not be affected : in most cases the duodenum alone shows any signs of irritation. The rectum is that part of the large intestine most prone to inflammation. The other internal organs—the liver, spleen, and kidneys—do not appear to be appreciably affected by arsenic.

Due probably to the antiseptic properties of arsenic, the stomach and intestines retain for a long period after death the appearances of irritant poisoning. In two cases, this was so well marked as to be visible—in the one case, *twelve* months, and in the other, *nineteen* months after interment. In suspected cases portions of the liver should always be preserved and examined for arsenic (see page 233).

The Period after Death when Arsenic may be Detected.

Arsenic is an indestructible poison, and may be found in the body after many years. In one case it was detected after the lapse of fourteen years. Arsenic has the power, to a certain extent, of arresting putrefactive changes ; the stomach may, therefore be found well preserved, and with the signs of inflammatory action present after the lapse of many months, and after putrefaction has far advanced in other parts of the body. When a person is suspected to have been poisoned with arsenic, and nothing but the skeleton is left for investigation, the arsenic should be looked

for especially in the bones of the pelvis, and the neighbouring spinal vertebræ. (Watt's "Dictionary of Chemistry," Sup.)

In trials for arsenical poisoning, where an exhumation has been made, the question may arise whether the arsenic found in the body has been carried into it from the earth surrounding the coffin.

In reply, the following points must be kept in mind :—

1. Arsenic may occur in certain calcareous and ochrey soils.

2. In these soils no arsenical compound *soluble in water* has been found.

3. The arsenic of these soils is dissolved out by hydrochloric acid, proving their previous insolubility.

4. The arsenic is, therefore, probably in the form of an arsenite or arseniate of iron, lime, etc.

5. Careful experiments have rendered it evident that even "under the most favourable circumstances the dead human body does not acquire an impregnation of arsenic from contact with arsenical earth" (TAYLOR).

6. It has been suggested that the arsenical compound in the soil may be rendered soluble by the ammonia formed during putrefaction.

This last suggestion is negatived by the following facts :—

1. The production of ammonia ceases before the body arrives at that stage of decomposition when it is at all likely to be exposed to the action of the soil of the cemetery.

2. The production of hydrosulphuret of ammonia during decomposition would tend to the production of sulphuret of arsenic forming yellow patches in the substance of the organs, thus rather fixing the arsenic on particular parts than allowing it to percolate through the tissues of the body from external application.

Analysis of the Suspected Earth. About two pounds of the earth should be boiled for some time in water ; the supernatant liquid should then be poured off from

the insoluble residue, and filtered. The filtered liquid, after concentration, may then be examined by the tests about to be described. If no arsenic be found, the earth may now be boiled with dilute hydrochloric acid, filtered, concentrated, and then tested as before. The first process shows that no compound of arsenic soluble in water is present; the second shows that the arsenic is in a state of combination, and therefore not likely to impregnate the body.

THE DETECTION OF ARSENIC.

General Directions.—In cases of suspected poisoning by arsenic or antimony, the contents of the stomach should be mixed with distilled water acidulated with hydrochloric acid and filtered, the filtrate placed in a stoppered bottle, and lettered or numbered 'A' or '1.' The liver should be cut into pieces, some of which should be bruised in a mortar with distilled water acidulated as above mentioned, pressed and filtered, the filtrate placed in a bottle, and marked 'B' or '2.'

The kidneys and portions of the other solid organs may also be treated as above. Each solution so obtained may be then tested by the processes about to be described. By these means the amount of poison in each organ may be estimated.

Before subjecting the organic mixture to Marsh's or Reinsch's processes, Brande and Taylor strongly recommend a modified course of procedure.

The contents of the stomach, vomited matters, etc., and the solid organs, finely divided, must each be separately and *thoroughly* dried in a water bath, then mixed with an excess of *strong* hydrochloric acid in a flask, and slowly distilled by means of a sand bath, the distillate carried into a receiver containing a little pure distilled water, and the process continued nearly to dryness.

If arsenic be present, the distillate contains the arsenic as chloride, and can be at once subjected with

great facility to the usual tests for the presence of that metal. This mode of proceeding both facilitates and expedites the ordinary methods of testing, as it separates the arsenic present from the complex organic mixtures with which it is associated, and presents it in a comparatively pure form for identification. The process also admits of the residue left in the retort being examined for lead and the other metallic poisons.

Before the following processes are applied, some of the sediment from the contents of the stomach, or the vomited matters, may be collected and well washed. If this is boiled in distilled water and filtered, the following tests, known as "the liquid tests for arsenic" may be applied to the filtrate :—

1. *Ammonia-Nitrate of Silver*, prepared by adding a weak solution of ammonia to a strong solution of nitrate of silver, gives with arsenic a yellow precipitate of *arseniate of silver* soluble in nitric, citric, acetic and tartaric acids, and ammonia.

2. *Ammonia-Sulphate of Copper*, prepared by adding ammonia to a dilute solution of sulphate of copper, gives with arsenic a green precipitate of *arsenite of copper*. This precipitate is soluble in the mineral and vegetable acids and ammonia, but is not affected by soda or potash. The precipitate dried and heated in a reduction tube, yields octahedral crystals of arsenious acid.

3. *Sulphuretted Hydrogen.*—The suspected liquid should be first slightly acidulated with *pure* hydrochloric acid *before* the sulphuretted hydrogen gas is passed into it, when, if arsenic be present, a yellow precipitate is formed, known to be such by the following tests :—

(1) Insoluble in water, ether, alcohol, the vegetable acids, and dilute hydrochloric acid, but decomposed by strong nitric and nitro-hydrochloric acids.

(2) Dissolved, if no organic matter present, forming a colourless solution, when potash, soda, or ammonia is added.

(3) The yellow precipitate dried and heated with soda and cyanide of potassium yields a sublimate of metallic arsenic.

N.B.—None of the above tests should be applied in the presence of organic matter. The soluble salts of cadmium and per-salts of tin give yellow-coloured precipitates with sulphuretted hydrogen.

The following TABLE gives the differences between the Yellow Precipitates formed with Sulphuretted Hydrogen and Arsenic, Cadmium, and Per-Salts of Tin :—

	ARSENIC.	CADMIUM.	PER-SALTS OF TIN.
Colour.	Yellow.	Yellow.	Dirty Yellow.
Action of Ammonia.	Soluble.	Insoluble.	Insoluble.
Action of Hydrochloric Acid.	Insoluble.	Soluble.	....
With Cyanide Flux.	Sublimes as metallic arsenic.	Sublimes as brown oxide.	No sublimate.

Marsh's Process.—This method for the detection of arsenic is founded on the fact that the several compounds of arsenic, except the sulphide and metallic arsenic itself, form a gaseous compound with nascent hydrogen, from which it may be readily separated by appropriate treatment. The solution to be tested should, therefore, be prepared as proposed by Brande and Taylor, given on a preceding page.

Precautions.—(1) Absolute purity of reagents. (2) The sulphuric acid should be diluted with five times its weight of water, and allowed to cool. (3) The suspected fluid should be added gradually. (4) Generate the gas regularly. (5) If no stain at once produced, keep a portion of the tube red hot for at least one hour.

The usual form of the apparatus is that of a U-shaped glass-tube, about one inch in diameter and eight inches high, supported in a vertical position on a wooden stand. One end of the tube is fitted with a tap, and terminates in a glass-tube drawn to a fine point ; the other end is closed with a cork.

The apparatus is used as follows :—A piece of pure zinc is dropped into the tube, and shaken into such a position that it occupies the bottom of that limb of the tube which is furnished with a tap. Water is

then added, and subsequently sufficient pure sulphuric acid to cause a moderately brisk evolution of hydrogen. The gas being allowed to accumulate for a short time, the tap is then partially turned on, and the gas ignited; if, on depressing a piece of white porcelain momentarily in the flame, no deposit or discolouration occur, the reagents used may be taken as pure. The tap is now connected with a tube of thin, hard glass, drawn out to a fine point at the end, and having a constriction in the middle. The liquid to be tested being now placed in the apparatus, the gas is again ignited, and a piece of white porcelain momentarily depressed in the flame, when, if arsenic be present, a black, circular, metallic-looking stain will appear, which has the following composition. In the centre is the unoxidised metal, round this is a mixed deposit, and outside this the zone of arsenious acid. While the gas is passing, the exit tube should be heated to redness a little behind the constricted part, when a dark ring will appear if arsenic be present. The black deposit on the porcelain may be either arsenic or antimony, but may be distinguished as follows:—

	ARSENIC.	AMTIMONY.
Nature of the Stain.	Metallic brilliancy.	Absence of metallic lustre.
Effect of Heat.	Volatile.	Non-volatile.
Heated with a little Nitric Acid.	Dissolves.	Oxidises to a white insoluble powder.
Warmed with a strong Solution of Chloride of Lime.	Dissolves immediately.	Slowly dissolved.
Treated with Bisulphide of Ammonium.	Detached but not dissolved, but if heated to drive off ammonia *yellow* sulphide formed.	Soluble; on evaporation, *orange yellow* sulphide formed.
The Nitric Acid Solution evaporated to dryness gives with Nitrate of Silver.	A brick-red precipitate soluble in ammonia.	No reaction, but if ammonia and potash are added, a black precipitate is ultimately formed.

The portion of the tube on which the dark ring has been deposited is now cut off, broken into fragments, and heated in a small, hard glass tube; when, if arsenic be present, a white sublimate will be obtained of well-defined octahedral crystals. If the sublimate be treated with sulphide of ammonium, it is detached but not perfectly dissolved, and on evaporation of the solution to dryness, a residue of the yellow sulphide of arsenic will remain, which, if heated with strong nitric acid, and evaporated again to dryness, will give a brick-red precipitate with nitrate of silver solution, soluble in ammonia. The process of Marsh may be used quantitatively by passing the issuing gas through a glass tube, dipping into a strong solution of argentic nitrate. A portion of the tube is kept at a red heat, when if arsenic be present, it is deposited in the metallic form in the cool portion. The glass tube containing the stain is cut with a file and weighed. The stain is then removed by strong nitric acid, the tube dried and weighed, the difference in weight equals the amount of metallic arsenic. The nitrate of silver solution is now treated with pure hydrochloric acid, filtered, and the filtrate neutralised with sodium carbonate, titrated with standard solution of iodine. By dipping the end of the issuing tube into a fresh solution of argentic nitrate, the absence of colour will show that all the arsenic has been obtained.

Reinsch's Process. First obtain a clear solution by filtration or otherwise, and then proceed as follows:—Strongly acidify the liquid with hydrochloric acid, introduce some pieces of copper foil, and heat to near the boiling-point of the liquid. Both the acid and metal must be previously tested to ensure their freedom from arsenic. Any arsenic present will then be deposited on the copper in the metallic state, either in the form of a black lustrous deposit, when the arsenic is present in any quantity, or else as a steel-grey coating

when a minute quantity only is present. In either case, the copper foil, after remaining for some time in the suspected fluid, is taken out, cut into small pieces, introduced into the bottom of a hard glass tube, and heated to low redness, when the arsenic will sublime as arsenious acid in octahedral crystals, forming a ring in the cooler portion of the tube. The deposit is identified as arsenious acid by the form of the crystals, and by its deportment with the various reagents, as in the treatment of similar sublimates mentioned under *Marsh's Process.* Two precautions have to be taken in applying this test: do not use too large a portion of copper foil at first, and do not remove the copper too quickly from the boiling fluid. A solution containing arsenic acid or an alkaline arsenite, mixed with sulphuric acid, does not produce any deposit on metallic copper even after long boiling, unless the quantity of the arsenic present be considerable; the deposition may, however, be ensured by adding sulphurous acid or a sulphite, whereby the arsenic is reduced to arsenious acid. (G. Werther J. pr. chem. lxxxii., 286; Jahresb. 1861. page 851.)

Objections to Reinsch's Process.—The chief objection to Reinsch's process is the possible impurity of the reagents used—both these reagents, even when supplied as pure, being liable to contain traces of arsenic. As met with in commerce, both hydrochloric acid and metallic copper invariably contain minute quantities of arsenic, the former generally containing the larger quantity of that impurity. Although, by purchasing the purest possible reagents, especially prepared for analysis, it may be possible to ensure their freedom from arsenic, yet in all cases they should be tested before using them. Some of the hydrochloric acid should be diluted with distilled water, and gently heated with the copper foil. If no tarnishing or deposit of any kind occurs on the metal after a lapse

of several hours, the reagents may be taken as pure and the trial of the suspected substance at once made.

Professor Abel has proposed the following process to ensure the purity of the copper and acid:—Boil together equal portions of strong hydrochloric acid and a solution of perchloride of iron. While the mixture is boiling immerse the copper foil, which, if pure, will be merely brightened in colour; if impure, a black deposit on the metal is formed.

Bloxam's Method for the Detection of Arsenic. Professor Bloxam has recently suggested an admirable and delicate process for the detection of small quantities of arsenic. The method is, like that of Marsh, founded on the property possessed by nascent hydrogen, of forming a gaseous compound with arsenic; but instead of the hydrogen being generated by the action of dilute sulphuric acid on zinc, Professor Bloxam generates the gas by an electric current.

The wires from the extremities of a battery terminate in small plates of platinum foil, which are plunged into the liquid to be tested, the apparatus being so arranged that the hydrogen gas evolved from the negative pole is collected. The issuing gas is tested in a similar manner to that obtained in Marsh's process.

This method of Professor Bloxam is exceedingly delicate, and possesses one great advantage, that no zinc being used, there is no danger of contamination by the use of impure metal; while, as nothing foreign is introduced during the process of testing, the liquid under examination is left pure for the application of other tests if necessary.

Fatal Dose.—Two grains in solution have been known to cause death. Recoveries have, however,

occurred after an ounce or more of the poison has been taken. Much will depend upon the fulness or emptiness of the stomach at the time the poison is taken, and also upon the vehicle in which the poison is administered. Vomiting and purging are more urgent when the dose is large, probably assisting to get rid of the arsenic before its fatal action is produced.

Fatal Period.—From twenty minutes to two or three weeks, and even later from the secondary effects of the poison. Any thick medium, cocoa or soup, will of course delay the action of the poison.

Treatment. — Vomiting should be promoted, and diluent drinks largely given. The stomach-pump, if it can be procured without much delay, should also be employed to empty the stomach. Emetics of sulphate of zinc should be given without delay — followed with the administration of milk, lime-water, and albumen. Symptoms as they occur must be treated on general principles.

The hydrated sesquioxide of iron, and the hydrated oxide of magnesia, and animal charcoal have been proposed and used as antidotes. The sesquioxide of iron can be prepared ready to hand by saturating the tincture *ferri perchloridi* with ammonia. It should be given freely. Reputed antidotes are useless when the poison is in the solid state.

Other Poisonous Compounds of Arsenic.

Arsenical Vapour.—The vapour from the flues of the copper and arsenic smelting-works in Cornwall, escaping into the air, may cause death to cattle, and the destruction of vegetation. The workmen in these works not infrequently suffer from eruptions on the skin, and from great constitutional derangement ; but,

on the whole, taking into consideration the dangerous nature of their employment, the men appear to enjoy average health. Actions for damage and nuisance have resulted from the escape of this vapour from the factories.

Arsenite of Potash.—A solution of arsenite of potash, mixed with the tincture of red lavender (the solution contains four grains of arsenious acid in one ounce) —better known as FOWLER'S SOLUTION, or as FOWLER'S MINERAL SOLUTION OF TASTELESS AGUE DROP. It is probably a solution of arsenious acid in carbonate of potash, and not a true arsenite of potash. This preparation is much used as a domestic remedy in ague in the Fens of Cambridgeshire. Death from its use is rare; but it is, nevertheless, too dangerous a medicine to be used recklessly. Idiosyncracy has much to do with the action of the drug, some persons taking even large doses with impunity, whilst, in others, the smallest medicinal dose has produced alarming symptoms. It is stated the Styrian arsenic-eating peasant is capable of taking without injury five grains of arsenious acid for a dose; and in one case of suspected murder in Styria, the prisoner was acquitted as the deceased was known to be an arsenic eater.

Donovan's Solution.—A solution of hydriodate of arsenic and mercury. Now officinal, and much used by many practitioners.

The mixture used for washing sheep, composed of tar-water, soft soap, and arsenic, has caused death in twenty-four hours. The men engaged in dipping the sheep may suffer both locally and constitutionally from the effects of the arsenic in the solution.

Treatment.—As before described.

Analysis.—See page 283 *et seq.*

Arsenite of Copper.—Scheele's green, and the aceto-arsenite of copper, Schweinfurt-green, are met with in commerce and the arts as green pigments. Among workmen they are familiarly known as emerald-green, Brunswick-green, or Vienna-green. In France, the term *vert Anglais* or English-green, has been given to them. Scheele's green contains about 55 per cent. of pure arsenious acid; the other Schweinfurt-green, about 58 per cent.

These colours are employed for various purposes, among which the following may be mentioned :—

1. Artificial flowers and other articles of dress.
2. Confectionary, pastry ornaments, and toys.
3. As green paint for the insides of houses.
4. In the green-colour for wall papers.
5. In the green-coloured paper lining boxes, etc.
6. Green-coloured tapers used for artificial lighting.

The employment of emerald-green in the colouring of wall papers is so extensive, that in the year 1860 an English paper-stainer stated that he used two tons of arsenic weekly. In 1862 the amount of this colour manufactured during the year was from 500 to 700 tons. As the colour is only loosely applied to the surface of the paper by means of a weak solution of size, it is easily brushed off, and may so impregnate the air of a room as to produce injurious effects on those who inhabit the apartment.

In the case of ladies' dresses, the following method is adopted :—

"The colouring material is made by thoroughly stirring together a mixture containing, in definite proportions, the green pigment, cold water, starch, and gum arabic, or some similar substance which shall give the colour consistence and adhesiveness. Not infrequently in this process the hand and fore-arm are freely used in the liquid to expedite the work. Of this mixture, properly prepared, the workman takes a quantity in his fingers and roughly

spreads it over the muslin or fine calico. The fabric is then beaten and kneaded between the hands until it is uniformly coloured. The longer this process is continued, the more perfect is the result. The cloth is now fastened to a frame for drying. In all this process of colouring, the hands, fore-arms, and frequently also the face of the operative, must become soiled with the green colour. It will be also observed that the colour is but loosely applied, *no mordant being used*, as in calico printing, to fix the pigment in the texture of the cloth."

Symptoms.—All the effects produced by arsenic may result from the use of articles coloured with these pigments. Chronic inflammation of the stomach and bowels, and irritation of the eyes, accompanied in some cases with extreme nervous debility and prostration, are by no means uncommon in those employed in the manufacture of this "cheerful," but poisonous colour. The skin of the hands, arms, and scalp is often attacked by a vesicular eruption or an erythematous redness. When it is borne in mind that, according to the analysis of Hoffman, a single twig of twelve artificial leaves may contain as much as ten grains of pure arsenic, it is not to be wondered at that the most serious results have occurred from the reckless use of these colours. In Prussia and France the use of the arsenical colours is prohibited.

Analysis.—Scheele's green is insoluble in water, but is soluble in ammonia, the solution having a blue colour, from the separation of the arsenious acid from the oxide of copper. If a few drops of the blue ammoniacal solution be poured on some crystals of nitrate of silver, the yellow arsenite of silver is formed. The blue ammoniacal solution, if acidified with HCl and boiled with pure copper foil, deposits arsenic on the copper, which, if cut into strips and placed in a small reduction tube and heated, sublimes and is deposited in octahedral crystals on the cold portion of the tube. The tests before described are applicable for the detection of this substance.

Orpiment.

Orpiment, or yellow arsenic, one of the sulphurets of arsenic, has been used occasionally as a poison. It is also largely employed in the arts for paper-staining and for colouring toys. In cases of arsenical poisoning it is this compound that is commonly found adhering to the stomach and intestines. It is formed by the sulphuretted hydrogen, the result of decomposition, acting on the white arsenic swallowed.

Realgar.

Realgar, or red arsenic, is another of the sulphurets of arsenic, and, like orpiment, is largely used in the arts as a colour. It is also employed, like orpiment, as a depilatory, fatal results having followed its use for this purpose. The colour of this substance prohibits its frequent use as a poison.

Both of these compounds owe their poisonous properties to the amount of free arsenious acid which they contain, and which may be as much as 30 per cent.

Symptoms. — The symptoms produced by these substances are similar to those caused by arsenic. The fatal dose will depend on the amount of free arsenious acid which they may each contain.

Treatment.—Emetics and demulcent drinks.

Analysis.—As before.

Metallic Arsenic, etc.

Metallic arsenic, fly powder, arsenic acid, largely used in the manufacture of magenta, aniline red or fuchsine, and the arseniates of potash and soda, are all poisonous. The *papier moure* of the shops consists of blotting-paper steeped in a solution of arseniate of potash. Macquer's neutral arsenical salt is the binarsenate of potash.

Symptoms.—The symptoms are those of arsenical poisoning.

Treatment.—When metallic arsenic has been taken, vomiting must be promoted by the use of proper emetics. Tartar emetic should never be used. In the treatment for poisoning with arsenic acid, or of the arseniates of potash and soda, the hydrated oxide of iron, or of the acetate of iron, should be used, as the arseniates are precipitated by the iron.

Arsenic Acid.

No case of poisoning by this substance has been recorded, for, although poisonous, it is better known in the laboratory than in the shops. It differs from arsenious acid in being only partially volatilised by heat, in its solubility in water, and in being precipitated of a brick-red colour by nitrate of silver. With sulphuretted hydrogen a yellow precipitate is slowly formed, insoluble in hydrochloric acid.

Arsenuretted Hydrogen.

This gas has proved fatal in several cases. It is generated in the process known as Marsh's process for arsenic, and is so poisonous that a very small quantity has caused death. In most cases death has been the result of accident.

Symptoms.—Giddiness, fainting, constant vomiting, pain in the stomach, and suppression of urine, are among the most prominent.

The *post-mortem* appearances are inflammation of the stomach, with more or less softening of its coats. The liver and kidneys are also more or less affected, and have been found of a deep indigo colour.

Analysis.—This has been described when speaking of Marsh's process for arsenic.

Recapitulation of the Leading Facts with regard to Poisoning with Arsenic.

ACUTE POISONING.—SYMPTOMS, ETC.

Action on alimentary canal.	Intense irritation of the stomach, upper part of small intestine, and lower part of the large. The inflamed condition of the stomach occurs even if arsenic be absorbed by the skin. Not present in *all* cases.
Circulation.	The heart weakened, with a consequent reduction in force and frequency of pulse.
The brain and nervous system.	In some cases the action upon the brain is that of a narcotic, and the paralysis sometimes seen appears to be due to a direct action of the drug on the cord.
The urinary organs.	Arrest of the action of the kidneys is not uncommon. Stranguary.
Fatal dose.	Two grains.
Average period of the commencement of symptoms.	From half-an-hour to an hour after the poison is taken.
Average period before death.	Ten to twenty-four hours.

CHRONIC POISONING.—SYMPTOMS, ETC.

The eyes, nose, and mouth.	Irritation and redness of the eyes and nostrils. Dryness of the mouth and throat.
The stomach and bowels.	Loss of appetite, colicky pains, cramps, irritability of bowels, mucous discharges.
Nervous system.	Depression and irritability of spirits, sleeplessness, giddiness, convulsions, vertigo, paralysis, etc.,
Cutaneous surface.	Brown pigment deposit in the skin of the face. "Eczema arsenicale," etc.
Means of diagnosis in suspected cases.	Examine the urine unostentatiously. Remove patient from present abode. Examine wall-paper, etc., for arsenic.
The probable *post-mortem* if death is due to this poison.	Signs of irritation slight or absent in stomach and bowels.
Organs most important to secure for analysis.	Liver, stomach, kidney.
Circumstances under which it may occur independently of criminal administration.	Green wall-papers, coloured toys and sweets, green tarltan dresses, etc.

ANTIMONY.

Antimony, the Stibium of the ancients, is obtained from the native sulphide. Metallic antimony is of a bluish-white colour, crystalline and brittle. It melts at about 840° F., and is slowly volatilised at a white heat.

Two compounds of antimony—tartar emetic and chloride of antimony—are alone of any toxicological interest.

Tartar Emetic.

Antimonium Tartaratum. Tartarated Antimony.

Tartar emetic occurs as a white powder; sometimes, however, with a yellowish tint. It is soluble in about three parts of boiling water and fifteen of cold, and insoluble in alcohol.

The *vinum antimoniale* of the Pharmacopœia contains two grains of the salt in an ounce of wine.

Before 1856 poisoning by antimony was of rare occurrence, but since that year several cases of chronic poisoning have occurred, giving to this substance considerable importance.

Symptoms of Antimonial Poisoning.

Acute.—Tartar emetic is an irritant poison, but possesses slight corrosive properties. When taken in large doses, two or three drachms, it gives rise to a metallic taste in the mouth, which is not easily removed. In most cases, violent vomiting follows immediately after the poison is swallowed, the vomiting continuing even after the stomach is emptied of its contents. In a few cases, however, even when a large dose has been taken, vomiting may be absent. Burning pain is felt at the pit of the stomach, accompanied with cramps in the belly, and purging. There is considerable difficulty in swallowing, and the patient complains of tightness

and constriction in the throat. The mouth and throat in some cases are excoriated, or covered with whitish aphthous-looking spots, which ultimately become brown or black. In some cases, the thirst is intense; in others, absent or nearly so. Cramps in the lower extremities, almost amounting in some cases to tetanic spasms, followed by extreme depression, are generally the precursor of a fatal termination. The urine is not suppressed, as is the case in arsenical poisoning; in some cases, it has even been increased. On this point, however, the statements of observers differ. Trousseau says that the urine is suppressed; Huseman that it is *never* suppressed. The skin is in some cases covered by a pustular eruption, not unlike that of small-pox. In antimonial poisoning, even in the most desperate cases, there is always greater hope of recovery than in arsenical poisoning.

Chronic.—The symptoms which mark the chronic form of poisoning differ chiefly in being less intense and less rapid than in the acute. Chronic poisoning by small repeated doses is that form of poisoning which appears most in vogue of late years—as certain diseases, enteritis, etc., can be simulated by the administration of repeated small doses. The unfortunate victim complains of constant nausea and retching, with great depression. Food is objected to, as it only increases the vomiting. The matters vomited are at first merely mucus, but after a time they become mixed with bile. Each time the poison is repeated, the symptoms become aggravated. Emaciation gradually sets in, and the person dies from complete exhaustion, or from the effects of a larger dose than usual. Chronic poisoning has given rise to several errors in diagnosis, and the histories of recorded cases should put medical men on their guard. In all doubtful cases, examine the urine.

Post-mortem Appearances.—The mucous membrane of the throat, gullet, and stomach is inflamed, and in

some places softened and corroded. Aphthous-looking spots are not infrequently found on the mucous membrane of the stomach, and these may also be observed on the throat and on the small intestines. The liver has been found in some cases of chronic poisoning, where the fatal termination has been for some time retarded, enlarged, and its structure so soft as to be easily broken down. Fatty degeneration of the internal organs has been found after protracted fatal administration of the drug. It is stated that in Brunswick the fatty livers of the geese are produced by the judicious administration of antimony. The appearances above detailed may be more or less absent or present, according to the time that may have elapsed from the swallowing of the poison to the time at which death has occurred.

Elimination of Antimony from the System.

Antimony, taken in a large dose, or in small doses frequently repeated, appears to be rapidly absorbed, and then eliminated from the system by the kidneys. Dating from the time at which the poison was swallowed, it will be found in the organs of the body in the following order :—

1. Stomach and bowels, but slightly in the liver.
2. Absent from the stomach, but present in the liver, spleen, and kidneys—traces in the blood.
3. Present in the fat and bones, with traces in the liver, fæces, and urine.
4. The period required for its complete elimination from the vital organs varies from fifteen to thirty days.

In other words, the presence of antimony in the stomach and intestines points to the recent administration of the poison; and its absence from those organs, and presence in the others above mentioned, to a more remote period of administration. It has been suggested that in some cases the poison may be eliminated by the mucous membrane of the stomach.

This assumption has been proved to be correct, for it has been shown that antimony may be found in the stomach after the inhalation of antimonietted hydrogen.

Fatal Dose.—It is impossible to state with certainty the exact amount of antimony—tartar emetic—which may prove fatal, as recoveries have taken place even after an ounce had been taken. Large doses are uncertain in their effects, as the severe vomiting which they produce generally helps to get rid of the poison. In small doses, death may result from the depressing action which it exerts over the heart.

Fatal Period.—From a few hours to several weeks, and even months.

Treatment.—Promote vomiting by the administration of warm water, or warm greasy water, and then give any vegetable infusion containing tannin—viz., tea, oak bark, or cinchona bark.

The Detection of Antimony.

Prepare the solutions of the liver and other solid organs, and also the contents of the stomach, as described under the detection of arsenic, using tartaric acid instead of hydrochloric acid. Through a portion of one of the solutions, obtained by filtration or dialysis, pass a current of sulphuretted hydrogen, which will produce, if antimony be present, an orange-coloured precipitate of the sulphide of antimony. The precipitated sulphide is dissolved by hot hydrochloric acid with the evolution of sulphuretted hydrogen; and if the resulting solution be poured into water, a white precipitate is formed of oxychloride of antimony, soluble in tartaric acid. Chloride of bismuth is precipitated when poured into water, but the precipitate is turned black by sulphide of ammonium, the antimonial orange red; the precipitate of bismuth is not soluble in tartaric acid, the antimonial is soluble.

Marsh's and Reinsch's processes may also be used for the detection of antimony. The former is, however, open to the objection that antimony, when present in any quantity, rapidly precipitates on the zinc in the form of a flocculent black deposit, while the issuing gas is found to contain only traces of the metal.

Reinsch's process is, however, very delicate, and its application is in every respect similar to that in use for the detection of arsenic. The acid liquid should, however, be boiled down to a small bulk with the copper, before a conclusion is drawn as to the entire absence of the metal.

Table giving the characteristic Reactions of Antimonial and Arsenical Deposits on Copper.

	ANTIMONY.	ARSENIC.
The colour of the deposit on copper by Reinsch's process is—	Lustrous, with a violet hue.	Dark steel-grey colour, and lustrous.
The coated copper heated in the end of a small tube.	No effect, or only a trifling white sublimate, non-crystalline, non-volatile.	Well marked sublimate of octahedral crystals; is readily volatile.

It may be noted that mercury likewise yields a deposit on copper with Reinsch's process; but the coating is in this case either of a grey colour or white, and silvery on the application of friction. When the coated copper is heated in a glass tube, there is a sublimate of metallic mercury readily aggregating into globules on being rubbed with a glass rod. If the deposit is trifling in quantity, a magnifying glass should be used to identify the metallic globules. This test at once distinguishes a deposit on copper due to mercury from that produced under similar conditions by arsenic or antimony.

Quantitative Analysis.—Take a measured quantity of the suspected liquid and precipitate thoroughly with sulphuretted hydrogen. Wash, dry, and weigh precipitate. One hundred parts equal 202·78 parts of crystallised tartar emetic.

Recapitulation of the Leading Facts with regard to Poisoning with Antimony.

ACUTE POISONING.—SYMPTOMS, ETC.

Action on alimentary Canal.	Intense irritation of the stomach and bowels, constant vomiting, and frequently purging. Eliminated by the stomach when absorbed by the skin, or as antimoniated hydrogen by the lungs. Presence, in some cases absence, of signs of inflammation in intestinal canal.
Circulation.	The cardiac contractions are lessened in frequency and force, the heart being finally arrested in diastole.
Brain and nervous system.	Sometimes delirium, paralysis of sensation and motion, and diminution of reflex action.
Urinary organs.	Secretion of the kidneys, as a rule, not arrested; sometimes increased.
Fatal dose.	Two grains.
Average period of commencement of symptoms.	A very short time after the poison is taken. Almost immediately.
Average period before death.	Various. Ten to twenty hours.

CHRONIC POISONING.—SYMPTOMS, ETC.

Mouth.	Aphthous spots on mouth, metallic taste.
The stomach and bowels.	Constant irritation, nausea, sinking at the stomach, symptoms of enteritis or cholera, purging, tenesmus, etc.
Nervous system.	Malaise, low spirits, giddiness, delirium.
Cutaneous surface.	Pustular eruption like small-pox, sweating, decrease in temperature.
Means of diagnosis in suspected cases.	Same as for arsenic.
The probable *post-mortem* if death is due to poisons.	Much the same as in arsenic poisoning.
Organs most important to secure for analysis.	Liver, stomach, and kidneys.

MERCURY.

Metallic mercury possesses no toxicological interest, as it appears to be almost inert, even in very large doses. The vapour given off from the metal is highly poisonous, producing salivation emaciation, and death. A singular accident of poisoning by mercurial vapour occurred on board H.M.S. "Triumph" in 1810, owing to the bursting of bladders containing large quantities of the metal; in three weeks 200 men were affected with salivation, etc., nearly all the cattle on board died, as well as the mice, a dog, and a canary-bird.

CORROSIVE SUBLIMATE.

This is the most important of the preparations of mercury. It either occurs in crystalline masses of prismatic crystals, or as a white powder. It is now known among chemists as the perchloride, though it is frequently spoken of as the bichloride, chloride, and oxymuriate of mercury. It has a powerful metallic and styptic taste, and is soluble in about sixteen parts of cold water and three of boiling water. Alcohol and ether readily dissolve it, *the latter having the power of abstracting it from its solution in water.* This property of ether is of importance as a means of separating corrosive sublimate from its solution in other liquids. It is important to remember that corrosive sublimate *is* soluble in alcohol (R. *v.* Walsh). The liquor hydrargyri perchloridi of the Pharmacopœia contains half-a-grain of the salt to a fluid ounce of water. Half-a-grain of the muriate of ammonia is added to increase the solubility of the mercurial salt. Applied externally to the unbroken skin, corrosive sublimate has caused death in several cases, the symptoms being almost identical with those which follow the entrance of the poison into the stomach.

Symptoms of Poisoning by Corrosive Sublimate.

Acute.—The symptoms come on almost immediately the poison is swallowed. A strong metallic coppery taste in the mouth is experienced, and a choking sensation in the throat. Pain of a burning character is felt, extending from the mouth to the stomach. Nausea and vomiting of stringent mucus, more or less tinged with blood, accompanied with violent purging, the evacuations being also mixed with blood and mucus. The pulse is feeble, quick, and irregular; the countenance flushed or pale, and the tongue white and shrivelled. This appearance of the tongue is not present in all cases. The skin is cold and clammy, and the functions of the kidneys are arrested, there being in many cases complete suppression of urine. As is the case with other irritant poisons, the symptoms and effects produced admit of considerable variation. Thus, there may be no pain in the stomach, and no purging. Salivation is present in some cases, but chiefly in those in whom the fatal termination is somewhat prolonged. This sign is not infrequently absent. Poisoning with corrosive sublimate differs from arsenical poisoning in the following particulars: — Corrosive sublimate has a distinct metallic taste, arsenic is almost tasteless; the symptoms in the former supervene immediately the poison is swallowed, in the latter there is a short delay. The discharges in corrosive sublimate are more frequently bloody than in arsenic poisoning.

Chronic.—The symptoms present in this form of poisoning are modified by the size of the dose, and the interval allowed to elapse between each dose. Nausea, followed by occasional vomiting, and pains in the stomach, are complained of by the patient. There is general constitutional disturbance, and consequent mental depression. Salivation, as might be expected

is a more prominent symptom than in acute poisoning; but the salivation may be intermittent—that is, it may cease and then reappear, even after the lapse of months, without an additional dose of mercury having been given in the interval. Salivation may also come on in the course of certain diseases, attacking the salivary glands, and it may also be produced by other causes—pregnancy, etc. The glands of the mouth become swollen and painful, the gums tender, and the teeth loosened fall out of the mouth. The breath has a peculiar, offensive smell, the bowels are irritable, and diarrhœa is not infrequently present. It must be borne in mind that in certain diseases—granular disease of the kidney—the smallest dose of any mercurial preparation may produce profuse ptyalism. And the toxicologist must be careful not to mistake the affection known as *cancrum oris*, or "the canker," most common in delicate, ill-fed children and adults, for the effects of mercury. The nervous system is more or less affected, neuralgic pains and mercurial tremors being present in many cases. Paralysis may also occur, especially in those exposed to the vapour of mercury. Habit appears to exert some influence on the action of corrosive sublimate, if we may accept the story of the old man of Constantinople, who for thirty years took large doses till his daily allowance was a drachm, and then died at the respectable age of one hundred years.

Post-mortem Appearances.—The morbid appearances are chiefly confined, as is the case with arsenic, to the stomach and bowels; but the corrosive action of the mercurial sublimate is more marked. Inflammation more or less intense is always present in the stomach, the mucous membrane of which may be found of a slate-grey colour, corroded, and so soft as to scarcely admit of the removal of the organ without tearing it. The cæcum and rectum are also sometimes found inflamed, and the mucous membrane softened.

Perforation of the stomach is very rare, only one case having been recorded in which this was present. The mouth, throat, and gullet may also present signs of the action of the poison similar to those just described as seen in the stomach.

Fatal Dose.—The smallest dose was *three grains* in the case of a child, but the exact amount to cause death in an adult has not been accurately determined.

Fatal Period.—From half-an-hour. No exact time can be stated.

Treatment.—Vomiting, if present, must be encouraged; if absent, it must be produced by emetics—zinc sulphate or cupric sulphate, followed with copious draughts of warm water. The hypodermic injection of a solution (2 per cent.) of apomorphia may also be used to produce vomiting. Albumen, the white of egg, or vegetable glutin produced from flour by washing it in a muslin bag, should be given. The rapid removal of the poison from the stomach, however, is the end to which all our exertions must tend. The stomach pump should not be used if it can possibly be avoided, as it may greatly injure the softened mucous membrane of the gullet and stomach.

Calomel.

Calomel or the subchloride of mercury, is not used as a poison. In large doses it may act as an irritant poison, and death has not infrequently occurred even from comparatively small doses. Profuse salivation and gangrene of the mouth have resulted from its use, and cases are recorded of death resulting from these. In many cases idiosyncrasy appears to modify, more or less, the action of this preparation of mercury. The poisonous effect of calomel has been attributed to —(1) Adulteration with corrosive sublimate. (2) Conversion of the calomel into corrosive sublimate by the action of the hydrochloric acid of the gastric juice.

N.B.—The free acid of the gastric juice is probably in too small a quantity to materially alter the composition of the calomel.

Ammonio-Chloride of Mercury.

White precipitate may, if taken in large doses, produce alarming effects, but it cannot be regarded as an active poison. Its action is that of an irritant, accompanied with, in some cases, severe salivation.

Red Precipitate,

Red oxide of mercury possesses poisonous properties, but it is seldom employed as a poison. The symptoms most frequently present are vomiting, coldness of the surface of the body, stupor, pain in the abdomen, and cramps of the muscles of the lower extremities. The vomited matters are generally mixed with some of the red oxide.

Cinnabar. Vermilion.

A compound of sulphur and mercury in the form of a dark-red crystalline mass is known as cinnabar; and to the same substance reduced to a fine powder the name vermilion has been given. It is used as a red pigment. It can scarcely be considered as a poison, Orfila asserting that it is not poisonous. The vapour of this substance appears, however, to be capable of producing severe symptoms, and in one case, profuse salivation resulted from the application of the vapour to the body.

Cyanide of Mercury.

This substance, though an active poison little inferior to corrosive sublimate, is seldom used as such, probably from its being better known to chemists than to the general public. It differs from corrosive sublimate in having no local corrosive action. It has been supposed, but proof is wanting, that its injurious effects are due to its decomposition by the acids of the

stomach and the formation of prussic acid. Death has occurred in nine days from a dose of ten grains. It acts as an irritant. The sulphocyanide of mercury is used in the manufacture of the toy known as Pharaoh's serpents.

Turbith Mineral.

A powerful irritant poison, but seldom used. A drachm has caused death in a boy sixteen years of age. Coldness of the surface, burning pain in the stomach and bowels, with other symptoms of irritant poisoning, were present. After death the mucous membranes of the throat, stomach, and bowels were found considerably inflamed.

Nitrates of Mercury.

These substances—the nitrate and sub-nitrate—are used in the arts for various purposes. They act as powerful irritant poisons, with symptoms and *post-mortem* appearances not unlike those before described when speaking of corrosive sublimate and other irritants.

Table showing the Reaction of Corrosive Sublimate with Reagents.

1. With solution of iodide of potassium.	1. Bright scarlet colour.
2. With potash solution.	2. Bright yellow colour.
3. With hydrosulphuret of ammonia.	3. First a yellowish and then a black colour is produced.
4. Heated in a reduction-tube.	4. It melts, boils, is volatilised, and forms a white crystalline sublimate.
5. With ether.	5. It is freely soluble in ether; and the ethereal solution, when allowed to evaporate spontaneously, deposits the salt in white prismatic crystals.
6. Heated with carbonate of soda in a reduction-tube.	6. Globules of metallic mercury are produced.

Detection of Mercury in the Tissues and in the Contents of the Stomach.

Mercury is particularly liable to be absorbed by the tissues; it also readily combines with various organic substances, gelatine, etc.

A.—If the contents of the stomach are under examination, they should be diluted with distilled water, filtered, the residue pressed and reserved for further examination.

The liquid thus obtained may be concentrated, and while still warm, slightly acidified with hydrochloric acid. A slip of zinc foil, with a piece of gold foil twisted round it, is then introduced. If mercury be present, the gold will, sooner or later, lose its yellow colour, and its surface become white and silvery, while the zinc is wholly or partially dissolved. The gold being removed, separated from the zinc, washed first with water and then with ether, is divided into two equal parts. One half may be heated in a reduction-tube, when it will yield a sublimate of metallic mercury, identified by the spherical form of the globules under a magnifying glass, and their metallic reflection and complete opacity. The other half of the gold may be treated with nitric acid and heated, which will dissolve off the mercury. The resulting solution, after expelling the excess of acid by evaporation, will give a scarlet precipitate with iodide of potassium soluble in excess; and with protochloride of tin, a black precipitate of metallic mercury.

B.—For the detection of mercury in the insoluble form, the residue from *A* is dried; or, if the tissues are under examination, they should be finely divided, and freed from superfluous moisture. In either case, the substance is boiled in moderately strong nitric or hydrochloric acid (about one part of acid to four of

water). After digestion for some time, the liquid is filtered, concentrated, and tested as in *A*. When there is reason to infer the presence of corrosive sublimate in considerable quantity in an organic liquid, advantage may be taken of the solubility of the salt in ether, and the power possessed by this liquid of abstracting it from its aqueous solutions. The liquid is agitated with an equal volume of ether, the ethereal solution poured off and allowed to spontaneously evaporate, when the corrosive sublimate will be left in white silky prisms, yielding all the characteristic reactions of the salt. In obscure cases of salivation, the saliva should be examined as follows :—Take about two drachms of the saliva, acidulate with pure hydrochloric acid, and immerse in the mixture a very small piece of copper gauze attached to a platinum wire, and set aside in a warm place for some hours. If mercury be present, the copper will be covered with a white coating ; this should be washed and heated in a reduction-tube, when globules of mercury will be formed, and examined with a lens.

According to Bonnewyn, the presence of an extremely small quantity of corrosive sublimate $\frac{1}{50000}$ in calomel may be detected by immersing a clean knife blade, moistened with alcohol or ether, in the suspected calomel. A black spot is formed on the steel very difficult of removal. No spot is formed when the calomel is pure.

LEAD.

Metallic lead is not poisonous ; but it appears probable that when it is acted upon by the acids of the intestinal secretions, it may become so changed as to produce unpleasant symptoms. Any salt of lead is poisonous when in a condition to be absorbed into the system.

Sugar of Lead and White Lead are alone important, and will therefore be briefly considered.

Sugar of Lead.

Acetate of Lead. Subacetate. Goulard's Extract.

General Character.—The acetate of lead, better known as sugar of lead, is not unlike loaf sugar in its general appearance. It is usually met with in the form of solid crystalline masses of a white or brownish-white colour. To the taste it is sweet, a metallic astringent taste being left in the mouth. Acetate of lead is soluble in water and in alcohol. The subacetate is a more active poison than the neutral acetate. Sugar of lead is popularly considered as an active poison, but this does not appear to be the case. Sir R. Christison gave eighteen grains daily in divided doses for eight or ten days with no other unpleasant symptoms than slight colicky pains in the abdomen. Lead is probably eliminated from the system by the urine, and also by the milk; but there is reason to believe that when once deposited in the body, some considerable time is required for its complete elimination. Dr Wilson is of opinion that in chronic lead poisoning the lead is more largely deposited in the spleen than in any other organ of the body. This organ should therefore always be carefully examined in suspected cases of poisoning by this metal.

Goulard's Extract is a solution of the subacetate of lead. It may be of a reddish colour, from the employment of common vinegar in the place of pure acetic acid in the manufacture.

Goulard's Lotion is the extract diluted with water.

White Lead.

White lead, carbonate of lead, ceruse or kremser white, is used as a pigment. It is generally in the form of white, heavy, chalky masses, insoluble in water, and, when taken in large doses, poisonous. It is this substance which, in the majority of cases, causes chronic lead-poisoning, or *painter's colic.*

The *chloride* and *nitrate*, the oxides, *litharge* and *red lead*, are all poisonous; but the *sulphate*, due probably to its insolubility, appears to be inert.

Lead poisoning may result from—

1. Constant contact with lead and its salts in manufactories.

2. Its use in the arts and as a pigment. The injurious effects of this substance are strikingly seen among painters, the makers of glazed cards, and the workmen engaged in preparing Brussels lace—this material being whitened by beating white lead into it. All thus employed are liable to suffer more or less from chronic poisoning.

3. Its application to the surface of the body in the form of ointment, plasters, cosmetics, and hair-dyes.

4. Drinking water impregnated with lead, from being stored in leaden cisterns or conveyed in leaden pipes.

"The action of water upon lead is much modified by the presence of saline substances. It is increased by chlorides and nitrates, and diminished by carbonates, sulphates, and phosphates, and especially by carbonate of lime, which, held in solution by excess of carbonic acid, is a frequent ingredient of spring and river water. But water highly charged with carbonic acid may become dangerously impregnated with lead, in the absence of any protecting salt, in consequence of its solvent power over carbonate of lead. In general, water which is not discoloured by sulphuretted hydrogen may be considered as free from lead; but there are few waters which have passed through leaden pipes, or have been retained in leaden cisterns, in which a minute analysis will not detect a trace of the metal; and were it not for the great convenience of lead, iron pipes and slate cisterns would, in a sanitary point of view, be in all cases preferable.

"Another case of contamination by lead may arise from electric action, as where iron, copper, or tin is in contact with or soldered into lead; and in these cases, owing to the action of alkaline bases as well as of acids upon the lead, danger may occur when it is thrown into an electro-negative as well as into an electro-positive state.

"Cisterns are sometimes corroded, and their bottoms are perforated by pieces of mortar having dropped into them, the lime of which has caused the oxidation of the metal, and a solution of the oxide."

5. Lead may also find its way into the system by means of the food. The use of leaden vessels in the manufacture of cider is attended with danger, and also the keeping of pickles in glazed earthenware jars. The celebrated "Devonshire Colic" was the result of cider-making in leaden vats. Rum has been known to have been dangerously impregnated with lead, leaden worms having been used attached to the stills. Many tobacconists are in the habit of using lead foil to wrap up their tobacco and snuff; this practice has resulted in several cases of chronic lead-poisoning.

Symptoms of Poisoning by Lead.

Acute.—A metallic taste in the mouth, accompanied with dryness in the throat and intense thirst, is experienced by the patient soon after the poison is swallowed. In some cases, however, *two* or *more hours* may elapse before the effects of the poison begin to show themselves. Vomiting may or may not be present. Twisting colicky pains are felt in the abdomen, relieved in some cases by pressure. The paroxysms of pain may be separated by intervals of ease. The bowels are, as a rule, obstinately confined, and the fæces are of a dark colour, from the formation of the sulphuret of lead. The skin is cold, the pulse quick and weak, and there is considerable prostration of strength. In some cases

the patient suffers from cramps of the calves of the legs, and sometimes, in protracted cases, paralysis of one or more of the extremities may supervene. The effect on the nervous system is marked by giddiness and stupor, terminating in coma, or convulsions and death.

Chronic.—This form of poisoning generally occurs among painters, manufacturers of white lead, pewterers, and others. The early symptoms are those of ordinary colic, only more severe. The patient generally complains, in the first instance, of feeling unwell, and of general debility. He then suffers from pain of a twisting, grinding nature, felt in the region of the navel. The bowels are obstinately confined. The appetite becomes capricious, and may be entirely lost. The mouth is parched, the breath fœtid, the countenance sallow, the skin dry, and general emaciation sets in. A nasty sweetish metallic taste in the mouth is present in most cases. Not infrequently the subjects of lead poisoning experience a peculiar form of paralysis of the upper extremities, well known as "dropped hand." It appears that this condition is the result of paralysis of the extensor muscles of the wrist. The muscles undergo a form of fatty degeneration. The lead appears to act primarily on the muscles, then on the nerves, and lastly on the nerve centres. One other symptom of importance has yet to be noticed. The gums, at their margins where they join the teeth, present a *well-marked blue line absent where a tooth has been removed.* This is not present in all cases, but it should be looked for.

N.B.—The symptoms produced by white lead—carbonate of lead—are those of *colica pictonum*, or *painter's colic*, described under the head of Chronic Lead-poisoning.

Post-mortem Appearances.—In acute poisoning the mucous membrane of the stomach and intestines is

inflamed, and is in some cases covered by layers of white or whitish-yellow mucus, more or less impregnated with the salt of lead swallowed. Corrosion of the mucous membrane may occur if the dose be large, and this condition is more frequently present when the neutral salt is taken.

In chronic poisoning there are no constant *post-mortem* appearances. The muscles of the paralysed extremity are usually found flaccid, of a cream colour, and the subject of fatty degeneration.

Fatal Dose.—Sugar of lead is not an active poison, recovery having taken place after one ounce had been swallowed.

Fatal Period.—Uncertain.

Treatment.—The free administration of the sulphates of soda and magnesia. The carbonates should not be given, the carbonate of lead being poisonous. Vomiting should be promoted, and a powerful cathartic administered. Albumen and milk should also be given, as these precipitate the oxide. In the chronic form of poisoning, the iodide of potash and aperients, notably the sulphate of magnesia, should be administered. Sulphur baths are also useful in removing the lead from the system. Lately the galvanic bath has been tried with great success. By way of *prophylaxis*, it has been recommended that all those engaged in lead manufactories, or who are obliged to handle this metal frequently, should partake largely of lemonade made with sulphuric acid, should not take their meals in the factories, or without well washing the hands.

Detection of Lead in Organic Mixtures.

The contents of the stomach or vomited matters must be diluted with water and filtered. The residue left on the filter, washed with distilled water, should be set aside for further examination ; the filtrate and

washings acidified with nitric acid. A current of sulphuretted hydrogen passed through the solution will then throw down the whole of the lead, should any of that metal be present, in the form of a brownish-black sulphide, which may be collected on a small filter and dried. The sulphide, boiled with dilute nitric acid, is partially converted into insoluble sulphate, and in part dissolved as nitrate. The carefully neutralised solution may be either tested at once or carefully concentrated. In either case, the production of a bright yellow precipitate, with a solution of bichromate of potash, and a similar one with a solution of iodide of potassium, may be taken as conclusive of the presence of lead. The portion of lead deposited as sulphate will be found to be soluble in a solution of pure potash, the resulting liquid giving a brown-black precipitate on the addition of sulphide of ammonium.

The insoluble residue left on the filter should be incinerated in a porcelain crucible, either with or without nitric acid, care being taken not to raise the temperature more than is necessary to produce the desired effect; the carbonised mass boiled with dilute nitric acid and then filtered, the filtrate tested as before-mentioned. It is often useful, as a preliminary test for the presence of lead in a soluble form, to dip a piece of bibulous paper into the clear liquid obtained by submitting the contents of the stomach or vomited matters to filtration, and then exposing the paper to the action of a current of sulphuretted hydrogen. If lead be present, blackening of the paper will take place.

[TABLE

Recapitulation of the Leading Facts with regard to Poisoning by Lead.

ACUTE POISONING.—SYMPTOMS, ETC.

Action on alimentary canal.	Sweet metallic taste in mouth. Vomiting, constipation, burning twisting pain in the belly. Inflammation of canal.
Circulation.	The pulse lowered, and tendency to death from syncope. Anæmia.
Nervous system.	Neuralgic pains, convulsions, cramps, etc.

CHRONIC POISONING.—SYMPTOMS, ETC.

Mouth and alimentary canal.	Sweet metallic taste; blue line at margins of gums; breath, fœtid. Colic, constipation.
Nervous and muscular symptoms.	Headache, delirium, stupor, amaurosis. paralysis of the extensor muscles of the wrist, anæsthesia of the affected part. Fatty degeneration of the muscles.
Circumstances under which it may occur.	Certain trades, as painters, plumbers, typefounders, etc. Action of drinking water on lead. Hair dyes, food in leaden utensils, etc.
Prophylaxis.	Grinding lead colours in oil or water. Cleanliness in factories, Slate cisterns for water. Dilute sulphuric acid lemonade.
Medical treatment.	Epsom salts, iodide of potassium, galvanic baths, etc.

COPPER.

Metallic copper, like metallic lead, is not poisonous, but its oxides are; it should, therefore, not be swallowed, as it is rapidly acted on by the intestinal secretions and poisonous compounds formed. An alloy of copper is used for ornamenting gingerbread, etc. All the salts of copper are poisonous. The most important are, however, the *sulphate*, *blue-stone*, or *blue vitriol*, and, the *subacetate* or *verdigris*.

Copper is eliminated to a slight extent by the urine. It has been found in the stomach, liver, and intestines eight months after its administration had been discontinued. It has also been detected more readily in the bronchial secretion than in the urine.

Symptoms of Poisoning by Copper.

Acute.—The primary action of the sulphate of copper in from five to fifteen grain doses is that of a quick emetic; in larger doses, a powerful irritant; but when absorbed, it appears to act chiefly on the brain and nervous system. Its irritant action is marked by nausea, vomiting, griping pain in the belly, which is greatly distended, and increased flow of saliva. The vomited matters are of a bluish or greenish colour, and the discharges from the bowels greenish and containing blood. The vomited matters become blue on the addition of ammonia. The above mentioned symptoms usually follow immediately after the poison is swallowed, and rapidly increase in severity. After a time, the remote effects supervene, marked by headache, giddiness, laboured breathing, quick irregular pulse, coma or convulsions, paralysis, and death.

In poisoning by this substance, the convulsions are most violent, and wild incoherent delirium not infrequent.

The subacetate of copper or verdigris produces symptoms not unlike those just described. Jaundice and suppression of urine may result when either this or the sulphate is taken.

Chronic.—Constant and troublesome irritation of the stomach and bowels; vomiting and purging, attended with considerable straining at stool; loss of appetite, loss of power, and general emaciation set in. The patient is subject to frequent trembling of the limbs, which may end in paralysis. The mouth is unpleasant, and a coppery metallic taste is experienced.

Cramps or colicky pains in the belly are not infrequently present. Jaundice is sometimes present. The vomited matters are greenish; but the practitioner must not be led away, and thus mistake the colour of the vomited matters which occur in some morbid states of the bile for that the result of poisoning by a salt of copper. A form of chronic poisoning affecting workers in this metal has been described by some French pathologists as "copper-colic." A cachectic condition of the system, accompanied with one or more of the symptoms already detailed, marks this form of poisoning. A *purple* line along the margins of the gums is present in some cases.

Copper poisoning may result from—

1. Its introduction into the system by using, for culinary purposes, copper vessels not properly tinned. An interesting account of poisoning from this source may be found in the second volume of the "Medical Observations and Inquiries by a Society of Physicians in London," published 1764. The cases there recorded occurred on board ship, with most alarming symptoms.

2. By constant application of the metal to the surface of the body, necessitated by certain processes in its manufacture and in its application for industrial purposes. M. Michel Lévy, however, says in his work, "*Traité D'Hygiène, Publique et Privée,*" that workmen in copper may pass green-coloured urine and yet be as robust and as long-lived as other workmen.

3. The use of certain preparations of this metal as pigment.

4. The use of German silver—an alloy of copper, zinc, and nickel—may be rendered dangerous by the action of acid food upon the compound.

5. The use of a salt of copper to give a green fresh colour to certain tinned vegetables and fruits, peas, etc., now introduced into this country from France.

Post-mortem Appearances.—The mucous membrane of the stomach is inflamed, the inflammation extending sometimes into the gullet. The intestines may be found perforated. The lining membrane of the whole alimentary canal presents a deep green colour, distinguished from that the result of a morbid condition of the bile by being turned blue on the addition of ammonia.

Fatal Dose.—Nothing certain is known as to the exact quantity that may prove fatal, as the evidence of the poisonous action of copper is somewhat contradictory. It appears to be more dangerous in small doses than in large ones.

Fatal Period.—The shortest time on record is four hours.

Treatment.—Induce vomiting, and assist the emetic action of the copper salts by the free use of warm water, milk, or any demulcent drink. As an antidote, large quantities of albumen and iron-filings have been given, of which the former appear to be most efficacious.

Detection of Copper in Organic Liquids.

A.—The finely divided tissue, or the contents of the stomach, diluted with water, are thrown on a filter, and the insoluble portion set aside for further treatment. (See *B.*)

The filtrate and washings may now be concentrated, acidified with sulphuric acid, and a polished needle inserted in the liquid; and should no immediate deposition of metallic copper occur, it may be allowed to remain for several hours. The colour of the metallic deposit is highly characteristic of copper. As a corroborative proof, the concentrated liquid may be placed in a platinum capsule with some fragments of zinc, when the copper will be deposited on the platinum capsule at the parts in contact with the zinc. The liquid poured

off, and the excess of zinc adhering to the platinum removed by dilute hydrochloric acid. The copper may now be dissolved off the platinum by nitric acid, the excess of acid driven off by heat, and the solution subjected to the following reagents:—

Ammonia—precipitates a blue hydrate of copper dissolved in excess of the reagent, and forming a blue solution.

Sulphuretted Hydrogen — gives a deep chocolate-brown precipitate, even in acid solutions.

Ferrocyanide of Potassium—gives a rich red-brown precipitate.

B.—The insoluble portion from *A* is incinerated in a porcelain crucible. The ash thus obtained is digested in hydrochloric acid with the aid of heat, and evaporated nearly to dryness. The residue, dissolved in water, may be tested as under '*A.*'

ZINC.

The sulphate and the chloride of zinc are alone important. Poisoning by the chloride of zinc has been described, page 266.

SULPHATE OF ZINC.—White vitriol or white copperas.

Symptoms.—The sulphate of zinc acts as a pure irritant. Violent vomiting, accompanied with pain in the abdomen, and purging, are the symptoms which first make their appearance. These may be followed with symptoms which betoken collapse, viz., coldness of the limbs, paleness of the face, irregular pulse, and fainting.

Post-mortem Appearances.—Presence of inflammatory action.

Fatal Dose.—Uncertain.

Fatal Period.—Death has occurred in four hours.

Chemical Analysis.—Distinguished from oxalic acid by remaining fixed when heated on platinum foil.

IN SOLUTION.—*Ammonia* gives a white precipitate soluble in excess. *Ferrocyanide of Potassium*, a white precipitate. *Sulphuretted Hydrogen*, a milky-white precipitate in a neutral pure solution. *Nitrate of Baryta*, a white precipitate showing the presence of sulphuric acid.

IN ORGANIC MIXTURES pass sulphuretted hydrogen, collect sulphuret, and decompose with boiling hydrochloric acid, then test for zinc.

Treatment.—Tea, coffee, milk, warm water, albumen, and in some cases enemata of gruel and other emollients.

IRON.

The preparations of iron which are of importance are the sulphate and the muriate.

SULPHATE OF IRON—*Copperas* or *Green Vitriol*—has been administered as a poison, but more frequently to procure abortion. An ounce has been taken with no other serious effect than the production of violent pain, purging, and vomiting. Constant application of this substance to the body has produced vomiting, pains in the belly and limbs. These symptoms disappear on treatment.

Chemical Analysis.—(1) Hydrosulphuret of ammonia gives a black precipitate. (2) Ferrocyanide of potassium added to it, in solution, gives rise to a greenish-blue precipitate, becoming dark-blue on exposure. (3) Chloride of barium will point to the nature of the acid present.

MURIATE OF IRON, better known as the *Tincture of Sesquichloride of Iron*, or the *Tincture Ferri Perchloridi.*—The tincture acts as a corrosive and irritant poison, death having followed in five weeks after an ounce and a half had been swallowed. Recovery has, however, taken place after three ounces had been swallowed. The symptoms present in most cases observed were those of a corrosive and irritant.

Chemical Analysis.—(1) The addition of nitrate of silver, causing a white precipitate insoluble in nitric acid, points to the presence of chlorine. (2) The peroxide of iron, indicated by the formation of Prussian blue on adding a solution of the ferrocyanide of potassium.

BISMUTH.

The preparations of this metal act as irritant poisons, death having occurred from a dose of two drachms of the subnitrate. Dr Trail ("Outlines of Medical Jurisprudence," page 116,) mentions the case of a patient of his who took *six drachms* in three days in divided doses. The symptoms were vomiting, extreme pain in the abdomen and throat, a weak, feeble pulse, and much anxiety about the præcordia. Recovery took place. Not long ago, in Scotland, a case of severe vomiting during pregnancy, ending fatally, was mistaken for arsenic poisoning. The error arose from mistaking a greyish powder on the walls of the stomach for arsenic. It turned out on further inquiry that it was bismuth, given medicinally to prevent the vomiting.

POTASSIUM.

NITRATE OF POTASH.—This substance is well known as nitre, saltpetre, and sal prunella. In large doses it acts as an irritant, and cases are recorded in which it has been used to poison children. In one case, the presence of crystals of the salt in some of the dried vomited matter on the child's shoe, led to an explanation of the cause of death.

Symptoms.—Those of a pure irritant, to which death must be referred, and not to any constitutional action of the drug. The nervous symptoms, which are sometimes very marked, are, as is well known, common to the action of many pure irritants. In some cases there is suppression of urine.

Post-mortem Appearances. — Those produced by irritants generally.

Chemical Analysis.—Separate the poison by dialysis, evaporate and test the crystals as directed under nitric acid.

Fatal Dose.—About an ounce.

Fatal Period.—Two hours.

Treatment. — The same as for other irritants; demulcent drinks. Promote vomiting.

Sulphate of Potash. — *Sal Polychrist, Sal de Duobus*, or sulphate of potash, acts as an irritant poison, being largely used in France as an abortive. The symptoms and the *post-mortem* appearances are much the same as those produced by the nitrate. A like treatment may also be adopted. In the detection of this substance, the nitrate of baryta will point to the acid present, and bichloride of platinum to the presence of potash.

Barium.

The chloride, nitrate, and carbonate of barium are all irritant poisons. But besides their irritant action, the salts of barium also appear to act on the nervous system and the heart, arresting its action in systole. The symptoms, *post-mortem* appearances, and treatment are the same as for the other irritant poisons. Sulphate of magnesia, or other soluble sulphate, should be given to form an insoluble sulphate of baryta.

Chemical Analysis. — Sulphuric acid or alkaline sulphate gives a white precipitate with solution of chloride of baryta, insoluble in nitric acid. The salts impart to flame a greenish-yellow colour. The chlorine is detected by nitrate of silver. Dissolve the carbonate in hydrochloric acid, and test as above.

Chromium.

Two compounds of this metal are largely used in the arts for dyeing purposes—the neutral chromate and the acid bichromate of potash. The bichromate of potash is a powerful poison, and death may occur from its direct action on the nervous system, without the development of any of the signs of irritation ; in other cases, however, well-marked irritant symptoms have been present. Applied externally, it produces deep fistulous sores, especially on the mucous membrane of the septum of the nose, in the workmen who are engaged in its manufacture. These sores are prevented to some extent by taking snuff. Dyers not infrequently suffer severely on their arms when using it in the course of their trade. Death has resulted in *four hours* after its administration.

Analysis.—A solution of the bichromate of potash, added to a solution of acetate of lead, gives a yellow precipitate ; with nitrate of silver, a red. The salt boiled with hydrochloric or sulphuric acid and alcohol, gives a green liquid.

Treatment.—Emetics, magnesia, chalk, demulcent drinks, etc.

VEGETABLE IRRITANTS.

Mode of Action.—The general effects produced by the somewhat large class of vegetable irritants are—

1. Severe abdominal pain, accompanied with vomiting and purging.
2. Absence in most cases of any cerebral or nervous symptoms.
3. The irritant properties appear to reside in an acrid oil or resin. In colchicum, stavesacre, and some others, the presence of an alkaloid may account for their active properties.

4. In medicinal doses, the vegetable irritants act as safe purgatives.

5. The *post-mortem* appearances found in the alimentary canal betoken inflammation, the result of irritation.

6. Applied externally, they produce inflammation, pustular eruptions, and sometimes unhealthy, callous sores.

SAVIN.

The leaves and tops of this plant, Juniperus Sabina *(N. O. Coniferæ)*, yield an acrid volatile oil, to the presence of which the poisonous properties are due. The oil is colourless or pale-yellow, with a peculiar terebinthinate odour. It is used in medicine both internally and externally, and is supposed to possess emmenagogue properties. The dried powder is less active than the fresh tops. Savin is seldom used as a poison, more frequently to procure abortion. Its use for this purpose is mentioned in the old ballad of Marie Hamilton :—

> "The King has gane to the Abbey garden,
> And pu'd the savin tree,
> To scale the babe from Marie's heart ;
> But the thing it wadna be."

Symptoms.—Those of irritant poisoning. Violent pain in the abdomen, followed by vomiting, and in some cases salivation and strangury. Purging is not always present. When taken to procure abortion, death often takes place before the object for which it was taken is attained.

Post-mortem Appearances. — The stomach, gullet, and intestines are found congested and inflamed. The stomach may in places be seen corroded, and a green powder adherent to its coats. The powder washed and dried, and then rubbed, gives off the odour of savin.

Analysis.—When an infusion or decoction of the leaves has been taken, chemical analysis is of no assistance. The oil may be separated from the contents of

the stomach by subjecting them to distillation, and then shaking the distillate with ether, when the oil is dissolved out. On the evaporation of the ether, the oil is left for examination. When the powder is taken the contents of the stomach are not unlike green pea-soup. If a small portion of the green liquid be taken, and diluted with water, the green chlorophylle, being insoluble, will sink; but if the colour be due to bile, the liquid will remain of a uniform green colour. A portion of the green matter collected, dried, and then rubbed in a mortar, the characteristic odour of savin will be given off. The microscope may detect bits of the twigs.

CROTON OIL.

The oil expressed from the seeds of *Croton tiglium (N. O. Euphorbiaceæ).*

The seeds, when taken, produce violent pains in the stomach and purging. Pereira has described the case of a man who suffered severely from inhaling the dust of the seeds. The dose of the oil is from half a minim to a minim. Dr Trail mentions the case of a delicate lady patient who took three drops for a dose without inconvenience. Dr Adam records a case ("Edinburgh Medical Journal," 1856,) of a man who, in mistake, drank three drachms of a liniment containing about fifty drops of croton oil. After the most alarming symptoms, the patient ultimately recovered. Two drachms and a half have caused death ("*Journal de Clinic Medicale*," 1839, page 509). The poisonous properties depend upon the presence of a fatty acid.

A medical friend informs me that in Shetland six drops in as many colocynth pills have, in cases there, only produced "a comfortable '*aisement*' of the bowels." This is attributed to the *dura ilia*, resulting from a constant fish diet.

Symptoms.—Pain in the abdomen, vomiting, and purging, followed by exhaustion and collapse. In some cases, when the dose is large, the pain is hot and burning, and may be felt from the mouth downward.

Analysis.—Separate the oil from the contents of the stomach by means of ether, and then drive off the ether by means of heat. The oil then warmed with nitric acid becomes of a brown colour, and nitrous acid vapours are given off.

COLCHICUM.

The poisonous properties of Colchicum Autumnale, Meadow Saffron *(N. O. Melanthaceæ)*, reside in an alkaloid *Colchicina*, chiefly found in the corms, but also present in other parts of the plant. The seeds have caused death.

In June 1875, an epidemic of gastric irritation among the inhabitants of Rione Boego was traced to the use of the milk of goats who had accidentally eaten the leaves of colchicum.

Symptoms. — Colchicum, in medicinal doses, increases the activity of the liver, and bile is freely secreted. The action of the kidneys and of the skin is also increased. The heart is more or less affected, and its frequency diminished. In large doses, all the symptoms of irritant poisoning are present, and in some cases have been likened to those observed in Asiatic cholera.

Post-mortem Appearances.—Death may result from its use without leaving any morbid appearances. In other cases, however, the usual signs of inflammation were present. Casper describes the colour and condition of the blood in those poisoned by colchicum as dark cherry-red, with the consistency of treacle. A marked congestion of the vena cava may also be present.

Analysis.—Colchicina, obtained by Stass' process, added to concentrated nitric acid, becomes of a violet colour, changing to blue and brown. Tincture of iodine precipitates colchicina of a kermes brown colour, platinum bichloride yellow, and tannic acid white, the precipate being soluble in alcohol, acetic acid, and alkaline carbonates

Fatal Dose.—One ounce of the tincture.

Treatment.—Stimulants and opium should be given to counteract its depressing defects. Tannin is said to be an antidote.

ERGOT.

Like savin, ergot is more frequently used to procure abortion than as a poison. When taken in a large dose it causes vomiting, purging, intense thirst, hurried breathing, and irregularity of the heart's action. Ergot appears to act powerfully on non-striated muscular fibre wherever it exists in the body; hence the vessels contract powerfully, and the peristaltic action of the intestinal canal is greatly increased. On the pregnant uterus its action is uncertain, as it does not appear to have any marked power in inducing labour, but on the parturient uterus its effects are most marked. A case is recorded in the "Lancet" (vol. ii., 1882), in which ergot had been taken for some time to procure abortion, but this end not being accomplished, the patient took "two hands full" of the powdered ergot to expedite matters, which caused the following fatal symptoms:—There was some amount of jaundice, and the expression of the face was anxious. Occasionally fits of stupor occurred, and the general condition of the patient was maudlin, but there was no smell of alcohol in the breath; but during the course of the case, which ended fatally, a distinct etherish smell could be perceived.

The pulse was so quick that it could not be counted, and it had also a peculiar jerky feel under the finger. Attempts were made to induce labour by passing a *bougie-a-boule*, but the patient died collapsed before delivery could be effected.

Where the drug has been taken for some time in the form of rye-bread made from the diseased grain, the symptoms in some cases are referable to the nervous system; in others, the blood appears to undergo certain changes; and hæmorrhages into the internal organs, as in the case just mentioned, have been frequently noticed. Gangrene of one or more of the extremities has also been known to occur. To chronic poisoning by this drug the term *Ergotism* has been applied, and may occur under two forms—the spasmodic and the gangrenous; the former marked by convulsions, giddiness, delirium, dimness of vision, and tetanic spasms; the latter, as a rule, by dry gangrene of the nose or extremities.

Analysis.—Ergot, has a peculiar, slightly fishy odour, which is increased by rubbing up the powder with liquor potassæ and heating the mixture. The production of this odour, and the appearance under the microscope, are the only tests yet known for this substance in powder.

Black Hellebore.

This plant, Helleborus Niger—Black Hellebore—*(N. O. Ranunculaceæ)*, known as the Christmas rose, is the melampodium of the old pharmacopœias. All parts of the plant are poisonous.

Symptoms.—Purging, vomiting, pain in the bowels, and cold sweats. Death is generally preceded by convulsions and insensibility.

Post-mortem Appearances.—Those common to the action of other irritants.

White Hellebore.—White Hellebore, Veratrum Album *(N. O. Melanthaceæ)*, acts very much in the same manner as the black hellebore, but is more powerful. The powder causes violent sneezing. The alkaloid *Veratria* appears to be the active principle. The symptoms and *post-mortem* appearances are analogous to those produced by black hellebore.

Gamboge is the gum resin of *Garcinia Morella.* It is an active ingredient in certain quack "vegetable pills." One drachm has caused death by its irritant action. Owing to the imperfect pulverisation of gamboge in quack pills, I have seen violent irritation of the bowels, straining at stool, and prolapsus uteri, due to the irritating action of small pieces of this substance.

Jalap, the powder obtained from the tubers of *Exogonium Purga.* The active properties of the drug reside in a resin. It is a drastic purgative, twelve grains having killed a dog.

Scammony is obtained from the dry root of *Convolvulus Scammonia.* Like the last mentioned, it is a powerful purgative, and may cause death if given in large doses to debilitated individuals.

Castor-Oil.—The oil expressed, with or without the aid of heat, from the seeds of *Ricinus Communis.* A girl, eighteen years of age, died in Liverpool in 1837 from eating a few of the castor-oil seeds.

Arum Maculatum. — Cucow-pint, Wake-robin, or Lords and Ladies, is one of the most acrid of indigenous vegetables. The active property of the plant appears to be lost by drying, and by distillation in water. Children have been poisoned by its leaves.

Yew.—The twigs and fruit of *Taxus Baccata* act as irritant poisons, producing also symptoms which point

to cerebro-spinal mischief. A case is recorded of poisoning by yew leaves, in which only five grains of the leaves were found in the stomach; yet death took place within an hour from the time the symptoms commenced ("British Medical Journal," 1876, vol. ii., page 392). In the above-mentioned case, vomiting and other signs of gastric irritation were absent. The chief symptoms present were — pallor of the face, faintness, an almost imperceptible pulse, facial convulsions, foaming at the mouth, stertorous breathing, loss of consciousness, ending in death. Several children have died after eating the fruit. *Post-mortem* signs of irritation of the alimentary canal.

Laburnum.—*Cytisus Laburnum*, or common Laburnum, the seeds, bark, and wood of which are poisonous. They contain a narcotico-acrid, crystallisable alkaloid—*Cystisine*—producing vomiting, foaming at the mouth, convulsions, and insensibility. Recovery took place in two cases mentioned by Trail, from the use of emetics and ammonia.

Fools' Parsley.—*Æthusa Cynapium* has been mistaken for Parsley. Nausea, vomiting, giddiness, and severe abdominal pains are among the most common symptoms of poisoning by this plant.

Bryony.—Two plants are included under this name, *Bryonia Dioica*, white bryony *(N. O. Cucurbitaceæ)*, the only indigenous cucurbitaceous plant, and the *Tamus Communis*, black bryony *(N. O. Dioscoreaceæ)*. Both the bryonia dioica and the tamus communis possess active irritant properties. They are of importance from the fact of their growing wild, and the possibility of the fruit being eaten by children.

Elaterium, the inspissated juice of *Ecbalium Officinarum*, or Squirting Cucumber. It is a powerful drastic purgative, one grain having given rise to alarming symptoms in man.

ANIMAL IRRITANTS.

CANTHARIDES.

Cantharides — *Cantharis Vesicatoria (N. O. Coleoptera)* — is seldom given as a poison, but is most frequently employed to procure abortion, or for its supposed aphrodisiac properties.

Cantharides is a pure irritant. Applied externally, it produces vesication; and if absorbed, strangury.

Cantharidine—the active principle of Cantharides—is insoluble in water and bisulphide of carbon. It is but slightly soluble in alcohol, but it is dissolved by chloroform, ether, and some oils. Four parts of cantharidine have been procured from a thousand parts of the flies.

Symptoms.—An acrid taste is first experienced in the mouth, followed by burning heat in the throat, stomach, and abdomen. There is constant vomiting of bloody mucus, and the stools also contain blood. The patient complains of intense thirst, pains in the loins, and an incessant desire to void urine, which is frequently mixed with blood. Salivation in some cases is a prominent symptom. Strangury may result from the external application of cantharides as a blister, etc. Priapism is often obstinate and painful and the fatal termination is generally ushered in by violent convulsions and delirium. In pregnant women, abortion may take place as a result of the general irritation and disturbance of the system there being no proof that the uterus is particularly affected by the drug. The vomited matters may contain shining green particles, the presence of which indicate the nature of the poison taken. The invasion of the symptoms may in some cases be retarded.

Post-mortem Appearances.—Those of powerful irritation. The mucous membrane of the whole alimentary canal, from the mouth to the rectum, has been found in a state of acute inflammation. The uterus, kidneys, and internal organs of generation, share also in the general irritation; ulceration of the bladder having been met with in some cases. Portions of the wings and elytra are sometimes found adhering to the coats of the stomach.

Fatal Dose.—One ounce of the tincture has caused death in fourteen days. This is perhaps the smallest fatal dose on record. Six ounces have been stated to have produced no dangerous symptoms. The worthlessness of the preparation may account for this result.

Treatment.—Vomiting should be promoted and warm mucilaginous drinks given. If vomiting be absent, emetics should be administered. Oil should not be given, as it dissolves out the active principle. Opium may be given with advantage.

Analysis.—The contents of the stomach should be concentrated and then treated with chloroform, filtered, and the filtrate allowed to spontaneously evaporate. A portion of the residue should then be placed on the skin, and the presence or absence of vesication noticed. Examined under the microscope, portions of the wing cases may be detected. No change of colour is produced in cantharidine by the action of sulphuric or nitric acid, thus distinguishing this substance from any of the vegetable alkaloids.

Mussels.—These not infrequently produce symptoms of irritant poisoning, sometimes attributed to the presence of copper, obtained from the copper coverings of the woodwork of jetties, to which they are very fond of adhering. One case which has lately come under my notice deserves mentioning from the peculiarity of

the symptoms present. A printer to whom I was personally well known, was sent to me by his employer. While at work he had suddenly become giddy, with loss of vision and difficulty of speech, and feeling, as he expressed it, very strange. When I saw him in my consulting-room, whither he had been sent, and which was about a mile from the place where he was taken ill, he was quite unconscious who I was, and asked my name, though he had seen me about an hour before. His eyes were staring, and the expression of his face was that of a man suddenly frightened. He could only speak with difficulty, stammering considerably. I ordered him home, and went to see him about an hour afterwards, when I found him in bed much better. His wife, in the meantime, had given him a dose of castor-oil. I also then learnt that he had partaken rather freely of mussels at breakfast, of which he was particularly fond. The next day he was much better, and went to work in a day or two after, but still felt "shaky." He ultimately got quite well.

Cheese.—Four cases of irritant poisoning have been recorded ("Lancet," 1873).

Sausages.—Symptoms of narcotico-irritant poisoning have followed the eating of sausages; and in the "Medical Gazette" for 1842, three deaths are attributed to the eating of sausages made from the liver of the pig. The poisonous principle has not yet been isolated, but by some it is considered to be the product of the partial decomposition of the fatty part of the sausage. The symptoms may not commence for three or four days after the sausages have been eaten.

Mutton.—A boy is reported to have died within three hours from the irritation produced by eating mutton.

TRICHINIASIS.

This disease is due to the introduction of the *Trichina Spiralis* into the human body. The encysted worm is found embedded in the fibres of all the striped muscles of the trunk and limbs, and even in the heart, where it appears in the form of white ovoid bodies or capsules, the capsules being sometimes calcareous. The worm passes the greater part of its existence in the chrysalis state in the muscular system of one animal, and only reaches its mature condition in the stomach of another. Virchow and Zenker assert that the trichina not only frequently presents itself in the human organism, but that this organism, is most favourable for its full development. Once in the stomach, the period of incubation is about six or eight days, and then propagation rapidly begins, and continues, so that Dr Kellen estimates that in a few days after the ingestion of half a pound of meat the stomach and intestines may contain thirty millions of the worms. The worms when introduced into the stomach leave their capsules, become free, produce young, and then leave the stomach through its coats for the muscles, where they become encysted. The trichina is most frequently found in pork, seldom in sheep, horses or oxen—the last being the freest.

Symptoms.—Intestinal irritation, loss of appetite, sickness, malaise, general weakness of the limbs, and diarrhœa. The eyelids swell as well as the joints, the skin is bathed in cold, clammy sweat, and a low form of fever sets in. Death may be due to peritonitis, paralysis of the muscles—the result of their destruction, or to irritative fever. During the perforation of the coats of the stomach aud bowels by the worms, the mucous membrane becomes inflamed, pus is formed on the surface, and the stools become bloody.

Treatment.—Medical treatment at present is hopeless.

THE ALKALOIDS.

Before entering on the discussion of the vegetable alkaloids, I must mention that M. Selmi of Bologna, in 1872 discovered certain alkaloids furnished by putrefaction in the stomachs of persons who had died a natural death, and which he showed were similar to the vegetable alkaloids. These substances were neither creatine or creatinine. MM. Brouardel and Boutmy have since investigated these alkaloids and confirmed the researches of M. Selmi. To these substances M. Selmi gave the name "*Ptomaïnes,*" the cadaveric alkaloids, from πτωμα, a corpse. Putrefied fish and cheese often contain toxic alkaloids and fatal results have frequently followed the ingestion of putrified food due to the presence of ptomaïnes.

Leucomaines (λευκωμα, white of egg), is the name given by M. Armand Gautier to the alkaloids secreted by living cells in their normal and abnormal states. The living animal cell he compares to the vegetable cell and has shown that both may secrete alkaloids, just as quinine, strychnia, etc., are secreted by the cells of the plant in which they are found. A toxic alkaloid, fatal to small animals, has been obtained from human saliva and from urine. M. Bouchard has succeeded in obtaining seven distinct toxic substances. The saliva and urine appear to be the chief channels by which these alkaloids are eliminated. Ptomaïnes and dïamines, belonging to the fatty series, are alkaline liquids forming crystalline salts, as a rule, with strong acids, and give precipitates with nearly all the usual reagents. Some are soluble in ether; others insoluble, but soluble in amylic alcohol or chloroform: some appear to be inert; others are decidedly poisonous. The nature of these substances demands further investigation, but it is not improbable that some of them may at least be

shown to be substitution products, the result of the action of bacteria on normal constituents of animal bodies. All the ptomaïnes appear to be reduced quickly by the ferrid-cyanide of potassium. To apply the test the ptomaïne is converted into a sulphate and added to a drop of the ferrid-cyanide in a watch-glass and mixed together. The reduction is shown by the formation of Prussian blue on the addition of a ferric salt. Some of the vegetable alkaloids also reduce the ferrid-cyanide, but more slowly; but aconite, morphia, and eserine are somewhat rapid in their action. To distinguish the vegetable from the animal alkaloids, Brouardel has suggested the following method:—A glass pen is used to write with a solution of the base on photographic silver bromide paper, protected from the light. In about half-an-hour the paper is washed with a solution of hyposulphite of soda, and then with water. If a ptomaïne be present the silver is reduced and the writing becomes visible. In the trial of Dr Lamson for poisoning his brother-in-law with aconitia, the presence of a ptomaïne was suggested.

METHODS FOR DETECTING VEGETABLE ALKALOIDS.

There are several methods recommended for the isolation and detection of the vegetable alkaloids, and their separation from the contents of the stomach or from the membranes and tissues of the body. The process, however, most generally pursued is that of Stass, which may be briefly described as follows:—

(*a*) The substance to be examined is mixed with twice its weight of absolute alcohol, to which from ten to thirty grains of tartaric or oxalic acid—preferably the former—have been added, and the mixture subjected to gentle heat in a flask, 70° to 75° C., or 158° to 167° F

(*b*) If the membranes or organs have to be examined, they are finely divided, treated with absolute alcohol, squeezed, and again treated with fresh alcohol as in (*a*).

In either case, the mixture, when quite cold, is filtered, and the alcoholic solution is concentrated by evaporation, either *in vacuo* or in a current of air not exceeding 95° F. or 35° C.

The liquid residue is now passed through a moistened filter, which separates the fat and other insoluble matters. The filtrate is evaporated to dryness over sulphuric acid or *in vacuo*, and the acid residue of this evaporation dissolved in the smallest possible quantity of distilled water. The acid liquid is then *gradually* neutralised with the bicarbonate of potash or soda until effervescence ceases, and afterwards shaken in a flask with four or five times its bulk of pure ether, and allowed to settle. When the ether has become quite clear, a small portion of it is decanted into a small glass capsule, and allowed to spontaneously evaporate in a dry place. If during evaporation, streaks of liquid appear on the side of the capsule, running together at the bottom, a liquid volatile alkaloid is probably present. If none of these manifestations occur, the alkaloid is in all probability solid and non-volatile.

If morphia has to be sought for, the liquid should be shaken with ether immediately after being neutralised with carbonate of sodium, and the ether poured off as quickly as possible; for if the alkaloid have time to separate in the crystalline form, scarcely any of it is dissolved by the ether (OTTO).

The method of Stass is based upon the fact that the salts of the alkaloids, as a class, are soluble in water and alcohol, but are insoluble in ether; and that these salts when in solution are readily decomposed by the mineral alkalies with the elimination of the alkaloids, which, in their free and uncombined state, are more or less readily soluble in ether.

The Alkaloid is Volatile.	The Alkaloid is Non-Volatile.
To the original mixture in a flask add a moderate quantity of a strong solution of caustic potash or soda, mixed with ether; agitate, and allow the mixture to settle. Pour off the ethereal solution, and re-shake residue with a fresh quantity of ether; decant, and mix both solutions. The ethereal solution is now shaken with a mixture of four parts of water and one of sulphuric acid, which withdraws the alkaloid from its solution, leaving any fatty matter dissolved in the ether. The acid solution is now mixed with strong potash or soda solution in excess,* agitated with ether, the ether poured off, and then evaporated at as low a temperature as possible,† leaving the pure alkaloid with all its characteristic chemical and physical properties.	To the original mixture in a flask add strong caustic potash or soda solution, and agitate with successive portions of pure ether, allowing it to completely settle each time. The ethereal solutions, being mixed, are evaporated, leaving the alkaloid in an impure state. To purify it, the solid residue left on evaporation is treated with a small quantity of dilute sulphuric acid, which dissolves the alkaloid, leaving any fatty impurities behind. The acid liquid is evaporated to three-quarters of its bulk over strong sulphuric acid, and then a saturated solution of carbonate of potash or soda added. The absolute alcohol will then dissolve out the pure alkaloid, giving it, on evaporation, in the crystalline form, and in a state to show its characteristic reactions.

OTTO'S METHOD.—Otto's modification of Stass' process is simpler, and at the same time equally accurate. Instead of numerous treatments and evaporations which have to be gone through in the original process, Otto converts the alkaloid into a salt, such as the sulphate, by the addition of acid, and after solution in a small quantity of water, agitates with successive quantities of ether, which remove all foreign fatty matters, leaving the solution of the alkaloid comparatively pure, and from which the alkaloid may be obtained in a state of great purity, by first rendering the solution alkaline, and then using ether to dissolve the alkaloid.

* The sulphates of alkaloids are insoluble in ether; hence they must be decomposed by an alkali.

† The temperature should be low, or the greater part of the conia will be evaporated with the ether.

R. WAGNER'S METHOD.—The presence of alkaloids in organic liquids—strychnia in beer, for example—may, according to R. Wagner ("*Zeitschr. Anal. Chem.*," iv., 387), be detected by mixing the liquid, diluted with two vols. water (½ to 1 litre), with about 5 c.c. of a solution of iodine in potassium iodide (12·7 grains iodine to the litre) and a few drops of sulphuric acid. The precipitate separated from the supernatant liquid is dissolved in a dilute solution of sodium hyposulphite, and again precipitated by means of the iodine solution. If this new precipitate be now dissolved in aqueous sulphurous acid, the solution will leave, on evaporation, the pure sulphate of the base.

M. DRAGENDORFF'S METHOD.—Recently M. Dragendorff has proposed a process for the separation, not only of the alkaloids, but also of the glucosides and other active principles of plants. The process is too elaborate for detail in an elementary work, but the student will find it fully described in Winter Blyth's book on Poisons. The process may, however, be briefly stated to be a combination of existing methods, with the exception that he removes all colouring matter and non-alkaloidal substances by first shaking up the acid fluid with the solvent, and secondly, the same fluid made alkaline.

The STASS process cannot be recommended for the detection of opium in organic liquids, for two reasons. Firstly, that it altogether fails to indicate the presence of meconic acid; and, secondly, because morphia is almost insoluble in ether. Dragendorff recommends the use of *benzole* for separating the alkaloids, but in this substance morphia is nearly insoluble. It is, however, applicable to strychnia, aconitia, conia, and atropia; but for the two last, on account of their volatility, ether is preferable.

The method recommended by TAYLOR may be briefly described as follows :—

The liquid—porter, etc.—to be examined is acidified with acetic acid; or, if a solid organ is to be tested, it must be cut into thin slices and placed in distilled water acidified in a similar way. In either case the liquid is digested for one or two hours at a gentle heat, and filtered. Acetate of lead is now added to the filtrate until no further precipitation occurs; the liquid is then boiled and filtered. The meconic acid remains on the filter as meconate of lead, while the filtrate contains the morphia as acetate. The liquid is freed from excess of lead by passing through it a current of sulphuretted hydrogen, filtered to remove the precipitated sulphide of lead, and the resulting liquid evaporated to an extract on a water bath, and treated with alcohol. The alcoholic solution on evaporation gives acetate of morphia, which may then be tested.

The meconate of lead which remains on the filter is decomposed by treating it with dilute sulphuric acid, and gently boiling the mixture. The filtered liquid should be neutralised before the tests for the presence of meconic acid are applied.

The reactions of both Morphia and Meconic Acid are best seen from the following Table :—

MORPHIA—SOLID.

Treated with strong nitric acid.	Dissolves with effervescence and the production of ruddy fumes, forming a rich orange-coloured solution.
Mixed with a little iodic acid and starch paste.	A blue colour, due to the liberation of iodine.
Dissolved in cold strong sulphuric acid, and a drop of strong solution of bichromate of potash added.	Bright-green colour.

Morphia and Meconic Acid in Solution.

	MORPHIA.	MECONIC ACID.
Tested with Litmus paper.	Slightly alkaline.	Very distinctly acid.
A little Perchloride of Iron, rendered as nearly neutral as possible.	An inky-blue colour, destroyed and changed to orange-red by nitric acid.	Deep red colour, not easily destroyed by a solution of corrosive sublimate or dilute mineral acids.

The characteristic tests for morphia are its reactions with nitric acid, iodic acid and starch, and perchloride of iron. The reaction with the perchloride of iron is also characteristic of meconic acid. This last-mentioned test is a very conclusive one for meconic acid, when certain precautions are taken; for the property of striking a deep red with a persalt of iron is shared equally by sulphocyanides and alkaline acetates. The colour produced by sulphocyanic acid *is instantly bleached* on the addition of *corrosive sublimate.* The question thus lies between acetic and meconic acid. To distinguish the one from the other, the solution to be tested should be boiled for a short time after the addition of a few drops of sulphuric acid. Any acetate present is decomposed, and the acetic acid is expelled by the boiling; so that if, after allowing the solution to cool, it still gives the red colour with perchloride of iron, the reaction may be taken as conclusive of meconic acid. By these means morphia and meconic acid may be detected in porter and other liquids.

[Table

TABLE SHOWING THE CHARACTERS AND TESTS OF THE FOLLOWING POISONS:—

MORPHIA.	STRYCHNIA.	BRUCIA.	NARCOTINE.
1. Crystallises in colourless transparent prisms, belonging to the trimetric system.	1. Crystallises in white four-sided prisms, terminated by four-sided pyramids.	1. Crystallises in oblique rhomboidal prisms, sometimes agglomerated mushroom-like heads.	1. Crystallises in right rhombic prisms, or in needles grouped in bundles.
2. Sulphuric acid and bichromate of potash give a bright-green colouration.	2. Treated with cold sulphuric acid, no reaction; on the addition of a crystal of potassium bichromate, an intense purple colour is produced becoming crimson and then light red.	2. Sulphuric acid gives a rich rose-pink tint; on the addition of potassium bichromate, none of the reactions of strychnia are observed.	2. Sulphuric acid a bright sulphur - yellow colour, potassium bichromate added a green colour as with morphia, but slower in production.
3. Strong colourless nitric acid, added freely to a cold solution, produces a deep orange-red colouration.	3. Strong nitrate acid usually produces a yellow or yellow-brown colour.	3. Strong nitric acid produces a blood-red colour.	3. Strong nitric acid forms a colourless fluid, becoming yellow on heating.

NARCOTIC POISONS.

SOMNIFEROUS.

OPIUM.

Opium is the inspissated juice of the *Papaver Somniferum*, the garden or opium poppy. The plant is a native of Egypt and Syria, cultivated in England.

Opium is sometimes taken in its crude state as a poison, but more frequently one of its preparations is thus employed—notably the tincture, better known as laudanum.

The poisonous properties of this drug reside in an alkaloid, *morphia* — in combination with an acid, *meconic acid.* The several varieties of opium vary considerably in the quantity of morphia which they contain, the amount varying from two to nine per cent.

Opium, or its alkaloid, morphia, forms an important ingredient in *Dalby's Carminative*, *Winslow's Soothing Syrup*, *Godfrey's Cordial Chlorodyne*, *Nepenthe*, etc.

Of all forms of poisoning, that by opium and its preparations is the most frequent; and it is stated that three-fourths of all the deaths from opium occur among children *under five years of age.*

Symptoms.—The rapidity with which the symptoms of poisoning by opium make their appearance will depend upon the form in which the poison is taken—solution, of course, increasing the activity of the drug. In most cases, an interval of from half-an-hour to an hour elapses after the poison has been swallowed before any evil effects become apparent. Christison, however, mentions a case in which stupor did not show itself for eighteen hours. During the first stage of poisoning by opium, the patient may become slightly excited; this state is, however, soon followed by giddiness and drowsiness. The eyes are kept open with difficulty. Stupor and insensibility now supervene, from which he may, in most cases, be temporarily

aroused by a loud noise or a smart blow. As the case progresses coma and stertorous breathing occur, and it becomes almost impossible to rouse him at all. The pulse, at first small, quick, and irregular, becomes slow and full as the coma increases. The breathing, hurried in the early stages, is now slow and stertorous. The pupils are contracted or dilated; the former condition is, in most cases, most frequently present, together with insensibility to light. The pupils may be contracted in cases of *hæmorrhage into the pons Varolii*, and cases of this disease have been mistaken for opium poisoning. In uræmic coma, coming on in the course of Bright's disease, the pupils may also be contracted; the nature of the case will be explained by the history and presence of dropsy. All the secretions, except that of the skin, are suspended, and the bowels are usually obstinately confined. The breath may be impregnated with the odour of opium. Certain anomalies in the symptoms may occur; thus, there may be vomiting and purging, convulsions (the last most frequent in children), delirium, tetanic spasms, one pupil dilated and the other contracted, paralysis and anæsthesia. It must be borne in mind that remissions sometimes occur in the symptoms, the patient dying after an attempt at recovery.

A question of some importance may arise as to the amount of volition and power of locomotion which may exist for some time after a poisonous dose has been taken. Death may be due to causes other than the effect of poison. It must, at least, be admitted as possible, that a person, after swallowing a quantity of opium, sufficient to cause death, may yet be able to walk and move about for from one to two hours.

Opium-eating.—If opium be taken for some time in small doses, the system becomes tolerant of it, so that a dose which would be poisonous to most people, only produces a slight and pleasurable excitement. De Quincey was in the habit of taking daily nine

ounces of laudanum. The habitual opium-eater generally suffers from disorders of the digestive organs, dyspepsia, and its train of unpleasant symptoms; the body becomes thin, the countenance attenuated, the eyes sunken and glassy, the gait halting, and the body bent. The craving for the drug which becomes greater and greater, is only temporarily satisfied by larger and larger doses. The opium-eater seldom attains a great age, usually dying before forty, This is perhaps a somewhat exaggerated picture of the ill effects of opium-eating. Christison, after quoting the results of his observations in twenty-five cases of confirmed opium-eaters concludes as follows:—"These facts tend on the whole rather to show that the practice of eating opium is not so injurious, and an opium-eater's life is not uninsurable, as is commonly thought, and that an insured person, who did not make known his habit, could scarcely be considered guilty of concealment to the effect of voiding his insurance. But I am far from thinking (as several represent who have quoted this work) that what has now been stated can with justice be held to establish such important inferences; for there is an obvious reason why, in an inquiry of this kind, those instances chiefly should come under notice where the constitution has escaped injury—cases fatal in early life being more apt to be lost sight of, or more likely to be concealed."

Effects of External Application.—The application of opium to the surface of the body is not usually attended with dangerous symptoms; but, in a few cases, due probably to some idiosyncrasy, alarming effects, or even death, has resulted from the external application of the drug. Orfila has tried to show that opium is readily absorbed by the coats of the rectum, and that it acts more rapidly than when taken into the stomach. This statement does not appear to be correct, for the dose administered by enema is usually twice that given by the mouth.

Post-mortem Appearances.—As might be expected, the appearances found after death are not very characteristic. The vessels of the brain are congested, and serous effusions in the ventricles or between the membranes are not uncommon. Engorgement of the lungs is most frequently present in those cases in which convulsions have occurred. The stomach is in most cases found quite healthy. The bladder may be full of urine, due probably to the person being unable to empty it from loss of consciousness.

Fatal Period.—From three-quarters of an hour and upwards.

Fatal Dose.—Four grains is about the smallest fatal dose in an adult; but cases of recovery, where an ounce or more of laudanum has been taken, are not very rare.

Treatment. — The stomach-pump should be used without delay, and the stomach thoroughly washed out. Emetics should also be given if the patient can swallow. The administration of strong coffee or tea, the application of ammonia to the nostrils, flagellation of the soles of the feet, and keeping the patient constantly walking about, are among the measures usually adopted by way of treatment. Galvanism and artificial inflation of the lungs have done good service even in the most hopeless cases. The student is referred to some important cases recorded by Dr Burgess and others in the "Medical Press and Circular" vol. i., p. 369, for the year 1892. Dr Burgess strongly recommends prolonged artificial respiration; the interrupted current, and the administration of stimulants, externally, internally and hypodermically. Dr Finny is of opinion that, while opium may be useful in cases of atropia poisoning, atropia is of little use in opium poisoning, in this opinion Dr Burgess concurred. The state of the respiration is a better test than the condition of the pupil when atropia is used as an antidote.

If the administration of atropia does not quicken the respiration it should be discontinued and other methods tried. Vinegar should not be given, as it dissolves the morphia and renders it more easy of absorption. Death is rare in those cases in which proper remedies have been resorted to before the stage of stupor has commenced.

Synopsis of the Effects of Opium Upon the System.

1. *The Mental Faculties.*—The first effect noticed when opium is taken in small doses is a primary exaltation of the mental faculties; the imagination is rendered brilliant, and the passions exalted; after a time drowsiness supervenes, followed by deep sleep. A dose of thirty drops of the tincture caused in one experimenter an exhilaration of the mental faculties, and an aptitude for study; the subsequent drowsiness being removed by a dose of a hundred drops or more, when the greatest mental excitement was the result.

2. *The Respiration.*—The frequency of the respiration is diminished, and the oxidation of the blood impaired.

3. *The Pulse.*—The first effect on the circulatory system is that of a stimulant, and then sedative. By the administration of repeated small doses, the force of the circulation may be maintained for some time.

4. *The Eyes and Countenance.*—The pupils, when the patient is powerfully under the influence of opium, are contracted even to a point. Dilatation, has, however, been noticed in some cases, especially when death approaches. In apoplexy of the pons Varolii, the pupils are contracted. The countenance is placid, pale, and ghastly; the eyes heavy, and the lips livid.

5. *The Cutaneous System.*—The skin, although cold, is not infrequently bathed in profuse perspiration.

6. *The Alimentary Canal.*—Sometimes there is vomiting and even purging; but, as a rule, the secretions along the whole alimentary canal are diminished, and constipation is the result. According to Dr Walter Smith, of Dublin, morphine is mainly excreted into the stomach and bowels and so cast out in the fæces. Very little goes out in the urine.

7. *The Average Commencement of Symptoms.*—Much depends upon the size and form of the dose. In most cases the first appearance of the symptoms is seldom delayed beyond an hour after the poison is taken.

8. *The Average Period of Death.*—Seven to twelve hours.

TABLE SHOWING SOME OF THE SYMPTOMS AND EFFECTS OF OPIUM AND BELLADONNA.

OPIUM.	BELLADONNA.
1. Slight excitement, coma, lethargy, and no return of the excitement should the patient recover.	1. Active, busy delirium preceding the coma, followed by delirium, if recovery takes place.
2. Coma is of shorter duration than in poisoning by belladonna.	......
3. Pupils contracted.	3. Pupils dilated.
4. Local application to the eye does not affect the pupil.	4. Dropped into the eye, the pupils are dilated.
5. Bowels as a rule confined.	5. Bowels not affected.
6. Acts powerfully on children.	6. Well borne by children.

Table showing the Points of Distinction between Apoplexy and Narcotic Poisoning.

APOPLEXY.	NARCOTIC POISONING.
1. Apoplexy *may* be preceded by premonitory symptoms, as giddiness, headache, noises in the ears, and partial paralysis.	1. No premonitory symptoms, except by fortuitous combination.
2. Apoplexy chiefly attacks the old, and is very rare in young people.	2. More frequently in the young, especially of the female sex.
3. Most frequently among fat people.	3. In fat or thin people.
4. Symptoms may come on during the meal or *immediately* after.	4. An interval of from ten to thirty minutes always occurs, even in the case of opium, the commonest of narcotic poisons.
5. The symptoms commence abruptly, sometimes with deep stupor.	5. The symptoms advance gradually.
6. Patient is with difficulty, if ever, temporarily aroused. Convulsions common. Face bloated. Pupils *dilated*, or irregular.	6. Patient may be roused from the deepest lethargy if shaken or spoken to in a loud voice. Convulsions rare in opium-poisoning. Face seldom bloated. Pupils *contracted*.
7. Life may be prolonged for a day or more. Apoplexy *may*, however, kill in an hour.	7. Life is seldom prolonged beyond six or eight hours. Shortest time in which opium has caused death, *three* hours.
8. No response when the forehead is smartly tapped with the finger nails, or when water is injected into the ear.	8. Patient may be roused by tapping the forehead, etc.

TABLE SHOWING THE CONDITION OF THE PUPILS IN—

Ordinary Sleep	The eyes turned upwards; pupils contracted.
Chloroform Narcosis	When the *liquid* is taken, coma; pupils dilated; eyes suffused or glistening, and turned upwards. When the *vapour* is inhaled, pupils first contracted; when coma supervenes, dilated.
Apoplexy	Pupils dilated; insensible to light. Sometimes unequal. Apoplexy of pons Varolii, pupils contracted.
Alcoholic Coma	The pupils dilated or variable, and not affected by a bright light placed before them.
Poisoning by Opium	Contracted in some cases to a pin's point; as death approaches, the pupils dilate.
Carbolic Acid	Contracted and insensible to light.
Calabar Bean	Powerful contraction of the pupils.
Hyoscyamus or Atropia ..	Dilatation of the pupils.
Strychnia	In some cases the pupils, during the paroxysms, are dilated, and contracted during the intermissions.
Aconite	Sometimes contracted; but in 17 out of 20 cases recorded by Dr Tucker, dilatation was present.

DELIRIANTS.

Under this head will be noticed those poisons whose action on the animal economy is characterised by *delirium*, illusion of the senses, and marked *dilatation* of the pupil. In some cases there is considerable irritation of the digestive organs, accompanied with a difficulty to pass water, sometimes ending in complete suppression of urine.

The following are among the most important poisons of this group :—

1. Belladonna.	4. Solanum Dulcamara.
2. Hyoscyamus.	5. Solanum Nigrum.
3. Stramonium.	6. Solanum Tuberosum.

Those of less importance are Œnanthe Crocata or Drop-wort, Camphor, Salicylic Acid, and Yew—the last already described among the Vegetable Irritants.

BELLADONNA.

Taken internally or applied externally, Belladonna, *Atropia Belladonna (N. O. Solanaceæ)*, or its alkaloid Atropia, causes dryness of the mouth and throat, with intense thirst. Nausea and vomiting are present in most cases, accompanied with giddiness, double or indistinct vision, active delirium, convulsions, ending in stupor and coma. A very marked characteristic of poisoning by solanaceous plants is *dilatation of the pupil*, the iris in some cases being reduced to a mere line round the pupil. The symptoms in some cases which have been recorded are almost identical with those of delirium tremens. In other instances there has been little or no delirium, the patient at once passing into fatal lethargy. Alarming symptoms have followed from drinking a decoction of belladonna leaves, which were mistaken and supplied for those of the ash. Accidental poisoning

has also frequently occurred among children from their eating the ripe berries of the belladonna plant. I have met with slight symptoms of poisoning from the use of belladonna plasters to remove the milk from the breasts of women delivered of still-born children, or in cases where the child has died soon after birth. In these cases the patients complain of intense dryness of the mouth, dimness of vision, and itching of the skin. The removal of the plasters will at once arrest the unpleasant symptoms.

In the "*Gazette des Hôpitaux*," July 1859, a case is recorded of poisoning by the outward application of belladonna in the form of the following liniment:—Camphorated oil of henbane, ten ounces; extract of belladonna, four scruples. The patient was seriously ill for some days, but ultimately recovered.

Poisoning has also resulted from the use of a solution of atropia (four grains to one ounce) dropped into the eye in the treatment of iritis. (See "British Medical Journal," vol. i., 1876.)

Post-mortem Appearances.—Congestion of the vessels of the brain, sometimes with fluid blood, at other times with thick black blood. The stomach may or may not be congested; but in cases where the ripe berries have been taken, the mucous lining may be seen deeply dyed by the juice of the berries. The pupils are usually found dilated.

Analysis.—From organic mixtures the alkaloid may be obtained by Stass' process, and treated according to Vidali with a little fuming nitric acid, and then dried in a water bath: when cold, it must be moistened with a drop of potassa dissolved in absolute alcohol. A violet colour changing to red is produced, the violet being characteristic, as strychnia when treated as above gives a red colour. The physiological action on the pupil must also be noted. When the berries are taken,

the mucous membrane of the stomach may be found dyed of a purple colour, turned green by alkalies and red by acids. Fragments of the berries may also be found in the stomach.

Treatment.—Emetics and purgatives, castor oil and animal charcoal. The symptoms as they present themselves must be treated on general principles.

N. B.—Belladonna has been stated to act in antagonism to opium, and its administration recommended in poisoning by that drug.

HYOSCYAMUS.

Hyoscyamus, *Hyoscyamus Niger*, or Henbane *(N. O. Solanaceæ)*, taken in large doses, produces symptoms not unlike those due to belladonna. There is the same affection of sight—double vision ; the same dilatation of the pupils, delirium, confusion of thought, insensibility, and coma. A form of mania, with wild hallucinations, has sometimes been observed to follow the administration of this drug.

The peculiar property of henbane is marked by its tendency to produce a general paralysis of the nervous system. The root has been eaten by mistake for parsnips, when all the symptoms above-mentioned were present. The seeds are more poisonous than the roots, the leaves being the least poisonous part of the plant.

Post-mortem Appearances.—The morbid appearances are not unlike those which result from poisoning with belladonna.

Fatal Dose.—Nothing certain can be stated as to the amount required to cause death. Alarming symptoms are said to have followed the administration of ten minims of the tincture, repeated every six hours. Twenty of the *seeds* have caused active delirium. Idiosyncrasy may have something to do with this result.

I seldom give less than half a drachm of the tincture to an adult, repeated every four hours, and have never seen any unpleasant result.

Treatment.—Emetics and purgatives, to expel the poison from the system.

STRAMONIUM.

The Thorn Apple, *Datura Stramonium (N. O. Solanaceæ)*, possesses powerful poisonous properties. These are marked by the production of giddiness, impairment of vision, and syncope. Furious delirium is not infrequent; and in one case where this state was present there was loss of speech. The face is usually flushed, the eyes glistening and restless, and the pupils dilated; in short, the countenance is that of one intoxicated. Taken together, the symptoms are not unlike those produced by belladonna.

Poisoning by stramonium seeds is a favourite mode of procedure among the Hindoos; but as the poison is most frequently given to facilitate robbery, death seldom results from its use. In India, the seeds are mixed with the boiled rice so commonly eaten there, and as they closely resemble the seeds of the common capsicum, the dangerous nature of the mixture is not readily detected. The seeds of the datura can be distinguished by the taste, which is slightly bitter, whereas that of the capsicum is hot and pungent. The outward application of the leaves may give rise to all the appearances of poisoning.

The active principle of stramonium is the alkaloid *Datura*, which crystallises in colourless quadrangular prisms, with a bitter acrid taste. It resembles atropia and hyoscyamia in chemical properties.

Post-mortem Appearances.—Congestion of the vessels of the brain and the membranes, with some slight gastric irritation.

Treatment.—Emetics and purgatives, to get rid of the portions of the plant swallowed.

Some other solanaceous plants—*Solanum Dulcamara*, Bitter-sweet or Woody-nightshade, *Solanum Nigrum*, or Garden-nightshade, and the *Solanum Tuberosum*, or Potato—possess poisonous properties. They, like the other members of the order to which they belong, give rise to symptoms characterised by giddiness, dimness of sight, trembling of the limbs, and delirium. The water in which the potato has been boiled is sometimes used by the vulgar as an application to favus of the scalp.

The active principle of these plants resides in an alkaloid, *Solania*, which is not a very powerful poison. A rabbit was killed in a few hours by two grains of the sulphate of solania.

ŒNANTHE CROCATA.

Hemlock, Drop-wort, or Dead-tongue, is a poisonous indigenous, umbelliferous plant.

Accidental poisoning by this plant has occurred, the root having been mistaken for parsnip. The symptoms in one of the cases which have been recorded were those of *delirium tremens;* in another, which terminated fatally, vomiting of blood was followed by convulsions. First contraction and then dilatation of the pupil, spasmodic respiration, and an almost imperceptible pulse were the effects noticed. Death may take place in a few hours.

Post-mortem Appearances.—Congestion of the vessels of the brain, and gastric irritation. The face has sometimes a bloated expression, and blood may escape from the ears and mouth.

Treatment.—Purgatives and emetics, to evacute the stomach, and thus get rid of the poison.

CAMPHOR.

Camphor is a concrete vegetable oil obtained from Camphora officinarum *(N. O. Lauraceæ).* Its employment for the purpose of homicide is rare, but several cases of accidental poisoning from the use of the homœopathic solution have been recorded ("British Medical Journal," vol. ii., 1873, page 617).

The symptoms are—languor, giddiness, delirium, foaming at the mouth, vomiting of blood-tinged fluid, convulsions, gastric irritation, and great abdominal pain. In one case—that of a young lady aged twenty, who took twenty-five drops of "Epps' Concentrated Solution of Camphor" for a sore throat—all the above-mentioned symptoms were present; she was also unconscious for several hours, and partially paralysed for several days—perfect recovery from the nervous symptoms not taking place for more than six months.

The homœopathic solution (Rubini's) is stronger than that of the British Pharmacopœia in the proportion of 7·2 to 1. For its detection in organic fluids, it may be removed by chloroform; and from fixed oils, by distillation. Water precipitates it from its alcoholic solution.

Post-mortem Appearances.—Those produced by irritants.

Treatment.—Purgation and emetics, to empty the stomach.

SALICYLIC ACID.

This substance, prepared by acting on a mixture of carbolic acid and sodium with carbonic acid at a moderate heat, has lately been lauded as almost a panacea for acute rheumatism, and like all new remedies, has been used on all and every occasion. In some

cases, premonitory symptoms of poisoning have demanded a cessation in the administration of the drug. The most usual of these were noises in the ears, difficulty of hearing, amblyopia, delirium, and profuse perspiration. When the drug was discontinued the symptoms passed off.

INEBRIANTS.

The poisons grouped under this head are characterised by causing delirium, followed by narcotism. Recovery is not infrequently slow, the system suffering more or less severely from the effects of the poison.

In the case of alcohol, loss of appetite, accompanied with considerable gastric irritation, are among the after-effects of the poison.

The chief of this group are—Alcohol, Cocculus Indicus, Poisonous Fungi, Nitro-Benzole.

Others of less importance will be briefly considered.

ALCOHOL.

It will be necessary to consider poisoning by this substance under two forms—acute and chronic. So many anomalies present themselves that it is difficult to give a clear outline of the symptoms.

Acute.—In most cases the symptoms come on within a few minutes after the poison is swallowed. Giddiness, confusion of ideas, and a difficulty in walking straight are among the first effects produced, these being followed by stupor and coma. Nausea and vomiting are the early signs of recovery. In some

cases there may be *no* premonitory symptoms, sudden and complete stupor supervening some time after a large dose of alcohol has been taken.

The patient not infrequently recovers from the first symptoms. A relapse takes place; he becomes insensible, and dies convulsed. The countenance wears a vacant expression; the face flushed and bloated, the lips vivid, and the pupils dilated and insensible to light. The sensibility of the pupil to the action of light should be regarded as a favourable symptom. The rapidity with which alcohol acts is not so great as to prevent the individual from walking some distance and performing certain acts of volition. The rapidity with which the symptoms show themselves will depend upon the previous habits of the individual, and the strength, and quantity of the alcohol taken. Alcohol, when diluted, induces a preliminary stage of excitement, followed by stupor; but when concentrated, stupor may come on almost immediately after the spirit is drunk.

The vapour of alcohol may act as a poison, giving rise to the symptoms above mentioned.

Congestion of the lungs or brain, or both together, is in most cases the cause of death in acute poisoning by alcohol.

Chronic.—The habitual dram-drinker suffers from many diseases. The appetite becomes impaired; there is considerable irritation of the stomach and bowels, marked by vomiting and purging. Then follows a long list of organic diseases. The structure of the liver becomes changed; it may increase in size, become lighter in colour, and is then known as "hobnailed" or *dram-drinker's liver*. Jaundice and dropsy may be present as the result of this altered condition of the gland. The kidneys also suffer from granular degeneration. Then follow a long series of nervous complaints:

congestion of the brain, paralysis, *delirium tremens*, and insanity. Sudden death by coma not infrequently ends the career of the drunkard.

Delirium tremens is one of the most common results of the habit of drinking; and this affection, it is stated, may be induced by the sudden discontinuance of alcohol in those who are habitually given to its use.

Post-mortem Appearances.—The stomach may present the usual signs of inflammation, due to the irritant action of alcohol. The colour of the mucous membrane of the stomach may be bright-red, dark-red, brown, or quite pale. The brain and its membranes are sometimes congested, and the intercranial vessels gorged with blood. The odour of alcohol may be present in the contents of the stomach; and alcohol may, in some cases, be detected in the lungs, brain, and other organs of the body. The lungs are not infrequently found congested, and the right cavities of the heart full of dark-coloured blood. Casper examined a case in which the cavities of the heart were empty. The blood is remarkably fluid, and of a dark colour. "Lymphatic exudation between the cerebral meninges, so that the pia mater upon the cerebral hemispheres is seen here and there whitish as if varnished, is not a result of death from drinking, but is the result of the chronic irritation of the brain by habitual drunkenness, and is therefore a very common appearance in the bodies of all drunkards, from whatever cause they have died." One other condition occurring in those dying from the effects of alcohol, is the remarkable long-continued presence of the *rigor mortis*, and perfect freedom from putrefaction, even up to the ninth day, in an atmosphere by no means unfavourable to early decomposition. A condition of the skin known as "*cutus anserina*," or goose skin, was present in some of the cases examined by Casper.

Absorption and Elimination.—From experiments on animals, it has been shown that alcohol is rapidly absorbed, and then eliminated from the system, and that all traces of alcohol may disappear in a few hours, and yet death be the result of its action. Alcohol is supposed to be decomposed in the body, but the exact changes it undergoes do not appear to be very clearly made out.

Fatal Period.—Death has occurred in a few minutes after a large dose of alcohol had been swallowed. The average fatal period is about twenty-four hours. Death may also be an indirect result of the action of alcohol on the system.

Fatal Dose.—Uncertain. The age and habits of the individual must be considered. Between three and four ounces proved fatal to a boy seven years of age.

Treatment—Immediate use of the stomach-pump and emetics, to empty the stomach. Affusion of cold water to the head, or the injection of cold water into the ears, may be tried. The administration of ammonia, and the employment of galvanism, have been of service in some cases.

[TABLE.

Table showing the Points of Distinction between Concussion of the Brain, Alcoholic Poisoning, and Poisoning by Opium.

CONCUSSION OF THE BRAIN.	ALCOHOLIC POISONING.	POISONING BY OPIUM.
1. Marks of violence on the head.	1. The absence of marks of violence, unless the person has fallen on the ground. The history of the case will help in forming an opinion.	1. Same as under Alcohol.
2. Stupor comes on suddenly.	2. Excitement previous to the stupor, which comes on suddenly.	2. The symptoms slow in appearing; drowsiness, stupor, lethargy. Muscles relaxed, and locomotion impossible. The patient may be roused by a sharp question.
3. Face pale and cold; the pupils sluggish and insensible to light, sometimes dilated.	3. Face flushed; and pupils generally dilated.	3. The face pale, pupils contracted.
4. Remissions are rare, the patient recovering slowly, and with some confusion of ideas.	4. Partial recovery may take place, followed by death after the lapse of some hours.	4. Remissions are, as a rule, rare in this form of poisoning.
5. Absence of the odour of alcohol in breath; if present, it is probably due to the treatment of bystanders.	5. Presence of the odour of alcohol in the breath.	5. Odour of opium in the breath.

Analysis.—Tests for alcohol :—

1. Characteristic smell.
2. It dissolves camphor.
3. Treated with dilute sulphuric acid and a strong solution of bichromate of potash, the green oxide of chromium is set free, and the vapour of *aldehyde* may be detected by the smell.
4. Burnt under the mouth of a test tube, moistened with solution of baryta or lime-water, a deposit is formed in the tube of carbonate of baryta or lime.

Alcohol in the Contents of the Stomach or in the Tissues.—The contents of the stomach, or the tissues bruised and macerated in distilled water, should be carefully distilled in a water bath. It will be necessary to neutralise the liquid prior to distillation. The distillate should be mixed with chloride of calcium or anhydrous sulphate of copper, and re-distilled. The liquid thus obtained is shaken with dry carbonate of potash, and allowed to settle. The alcohol rises to the top of the mixture, whence it may be removed by the aid of a pipette, and tested as before-mentioned.

COCCULUS INDICUS.

The fruit of Cocculus Indicus, *Anamirta Paniculata, (N. O. Menispermaceæ)*, is poisonous, and is frequently used by poachers to capture fish. The berries are ground to powder, mixed with bread, and then thrown into the water. When taken by the fish, they become stupified, float to the surface, and are then taken.

The poisonous properties are due to a crystalline alkaloid, *Picrotoxia.* Fraudulent publicans have used this drug for the adulteration of beer. The strength of the beer is first reduced by the addition of salt and water, and then the cocculus indicus is added, to give to it an intoxicating property. The effect produced on the unfortunate customers is a strong desire to sleep, with more or less wakefulness. Loss of voluntary power is present, but consciousness is not lost, the sufferer lying in a state bordering on nightmare. Cocculus is not used

in medicine or the arts, and yet a large quantity is imported, and mysteriously disappears in this country.

The symptoms which have been noticed in poisoning by this substance are—nausea, vomiting, severe abdominal pains, stupor, and intoxication. Two deaths at least have been reported as resulting from it. In the case of R. *v.* Cluderay, "the defendant administered to a child two cocculus indicus berries, entire in the pod, with intent to murder the child. The kernel is a poison; the pod is not, and will not dissolve in the stomach; and they were therefore harmless. This was held to be administering poison with intent to murder, within the section of the Statute."

Picrotoxia.—The alkaloid is in fine white crystals, intensely bitter to the taste. Soluble in boiling water, slightly so in cold. Alcohol and ether readily dissolve it. Strong nitric acid dissolves it, without change of colour; and sulphuric acid produces an orange-yellow colour, changed to pale yellow by dilution. In organic liquids it might be mistaken for sugar, or *vice versa*, as it precipitates the oxide of copper when boiled with the sulphate of copper and potash. In examining beer supposed to be adulterated with picrotoxia, the beer should be acidulated with hydrochloric acid, and then shaken up with ether. On spontaneous evaporation of the ether, the picrotoxia is left in crystals.

Treatment.—Stomach-pump, emetics, apomorphine subcutaneously. Then chloral and the bromide of potassium.

LOLIUM TEMULENTUM.

The seeds of *Lolium Temulentum*, or common Darnel, are poisonous. Cases of poisoning have occurred from these seeds being accidentally ground with wheat or rye, and then made into bread.

The symptoms are—gastric irritation, nausea, and vomiting followed by giddiness, deafness, loss of vision,

and, in some cases, delirium. Not infrequently, the symptoms resemble those produced by ergot. No death has been recorded as resulting from the use of these seeds. Three ounces of paste made from darnel flour, given to a dog, did not cause death.

POISONOUS FUNGI.

Accidental poisoning by Mushrooms is by no means rare. The *Agaricus Campestris*, and a few others, are edible; but it is a fact worthy of notice, that the poisonous properties of mushrooms are modified by climate, and the seasons of the year at which they are collected. Idiosyncrasy may have something to do with the injurious effects produced on some persons by the fungi.

The *Agaricus Campestris*, or common mushroom of this country, is sometimes poisonous; and in some countries—Italy and Hungary—it is usually avoided. In Russia and in France certain fungi are eaten which are regarded as poisonous by us.

BENTLEY gives, in his "Botany," the following Table, by which Edible and Poisonous Mushrooms may be known:—

EDIBLE.	POISONOUS.
1. Grow solitary, in dry airy place.	1. Grow in clusters in woods and dark, damp places.
2. Generally white or brownish.	2. Usually with bright colours.
3. Have a compact, brittle flesh.	3. The flesh tough, soft, and watery.
4. Do not change colour by the action of the air when cut.	4. Acquire a brown, green, or blue tint when cut and exposed to the air.
5. Juice watery.	5. Juice often milky.
6. Odour agreeable.	6. Odour commonly powerful and disagreeable.
7. Taste not bitter, acrid, salt, or astringent.	7. Have an acrid, astringent, acid, salt, or bitter taste.

Two sets of symptoms may follow the use of mushrooms as food—those of irritant and those of narcotic poisoning. In the latter class, giddiness, double vision, and even delirium, have been present. Nausea, vomiting, purging, and convulsions characterise those of the former class. In some cases the individual has presented all the appearances of intoxication. The *post-mortem* appearances will depend to a great extent upon the character of the symptoms prior to death. If signs of irritation have been present, inflammation of the stomach and bowels will most probably be found; but if, on the other hand, narcotic symptoms were predominant, congestion of the vessels of the brain will most likely be present. Arsenic and other poisons have been mixed with mushrooms with intent to kill; the probability of this occurring should be borne in mind, and a rigid examination of the contents of the stomach made in all doubtful cases.

Treatment.—Castor-oil and emetics.

NITRO-BENZOLE, OR ESSENCE OF MIRBANE.

This substance, prepared by acting on Benzole by nitric acid, is largely used for flavouring sweets, etc. Nitro-benzole is a heavy, yellow, oily substance with a strong odour of bitter almond oil, from which, however, it differs by undergoing no change of colour when agitated with strong sulphuric acid. The natural oil acquires a fine crimson colour when treated with strong sulphuric acid.

Symptoms.—These may not make their appearance for three or four hours after the poison is swallowed or inhaled. The vapour is more powerful than the liquid. In some cases which have been described, the patient has complained of feeling drunk, with pain in the head, giddiness, faintness, distorted vision, drowsiness, ending

in coma and death. The face is flushed, the jaws sometimes spasmodically closed, and the lips vivid. Vomiting then supervenes, the vomited matters having the odour of bitter almonds. Symptoms not unlike those produced by prussic acid or the essential oil of bitter almonds have been noticed in one or two cases; but, as a rule, the insensibility is not immediate, as in prussic acid poisoning, and in this fact lies the distinction between the two substances. Rapidly fatal cases might be mistaken for apoplexy, but the odour betrays the cause of death.

Post-mortem Appearances.—Nothing very characteristic is found after death due to this poison. The blood is sometimes black and fluid and gives the spectrum of acid hæmatin, the lungs congested, and the liver of a purple colour. The blood, contents of the stomach, and even the tissues, may smell strongly of this substance.

Analysis.—Nitro-benzole may be separated by distilling the organic mixture with sulphuric acid, when the distillate will contain the poison if present. It is converted into analine by heating it with acetic acid and iron filings. (See test for Analine, *infra.*) On account of its odour, the only substance with which it can be confounded is the essential oil of bitter almonds, which owes its poisonous properties to the prussic acid it contains.

Treatment. — Stomach pump, emetics, stimulants, cold douche, artificial respiration.

The following Table may assist in its Detection:—

	NITRO-BENZOLE.	OIL OF BITTER ALMONDS.
Strong Sulphuric Acid.	No change of colour.	A rich crimson colour.
Proto-sulphate and the Persulphate of Iron, Liquor Potassæ, and Hydrochloric Acid.	No blue colour.	Prussian blue.
Solution of Sulphate of Soda.	Insoluble.	Soluble.

Aniline.

This substance is not unlike nitro-benzole in its physiological action. The vapour causes giddiness, and other signs of intoxication. The workers in aniline are said by Dr Kreuser to suffer from bronchitis, cough, and ulceration of the scrotum and limbs. In dyers, eczema of the skin is sometimes found. The eruption on the feet of some persons produced by socks is said to be due to the presence of arsenic, which enters into the composition of some of the aniline dyes.

Analysis.—Aniline is almost insoluble in water or chloroform, but is soluble in alcohol, ether, and oils. On the addition of chloride of lime or an alkaline hydrochlorite to a watery solution of aniline, a splendid purple colour passing into a dirty brownish-red is produced. A white compound, soluble in water, is formed when aniline is added to dilute sulphuric acid. Heated with corrosive sublimate, a rich crimson colour is produced.

Fusil Oil, Amylic Alcohol, Potato-Spirit.—Fusil Oil, also known as Amylic Alcohol, is known by its unpleasant odour and burning taste; it acts like alcohol as an inebriant, giving rise to headache, giddiness, etc.

Nitro-Glycerine. — In liquid or vapour, violent headache and throbbing in the temples are produced by this substance, which has lately been proposed in the treatment of angina pectoris.

SEDATIVE POISONS.

CARDIAC.

DIGITALIS.

The common foxglove, *Digitalis Purpurea (N. O. Scrophulariceæ)*, grows wild in the hedges in the South of England. All parts of the plant are poisonous, from the presence of an alkaloid—*Digitalia.*

Symptoms.—Nausea, salivation, vomiting, purging, and severe abdominal pains are first noticed. The patient then complains of pain in the head, giddiness, and a gradual loss of sight. The eyes protrude, the pupils are dilated and insensible to light, and the sclerotics, according to Tardieu, are of a characteristic blue colour ; the pulse weak, slow (forty in the minute), and jerky, sometimes intermittent. The surface of the body is cold, and bathed in perspiration. An aggravation in the symptoms takes place whenever the patient attempts to leave the recumbent position ; hence, in all cases of poisoning, and in those where the therapeutical action of the drug is sought, the patient should be warned of the danger of leaving the recumbent posture. A marked depression in the action of the heart is a characteristic effect of this poison. The effect on the heart may be divided into three stages—(1) Diminution in the frequency of the pulse, and rise of arterial pressure ; (2) both of these become abnormally low ; (3) frequency of pulse abnormally high, arterial pressure abnormally low. Convulsions have sometimes been noticed, and syncope and stupor are not uncommon.

Post-mortem Appearances.—Congestion of the brain and its membranes, and some inflammatory redness of the mucous membrane of the stomach. The blood is fluid.

Fatal Dose.—Uncertain. Large doses of the infusion and tincture have been given without any untoward results.

Treatment.—Purgatives and emetics should be given, followed by infusions containing tannin, green tea, oak bark, galls, strong coffee, and other stimulants. The patient should be kept in the recumbent posture, and on no account allowed to sit up.

Analysis.—If the leaves in an infusion be taken, these must be sought for and examined.

Digitalia.—The alkaloid found in the Foxglove.

Tests :—

1. An almost amorphous, white, or fawn-coloured inodorous substance.
2. Almost insoluble in water.
3. Decomposes nitric acid, with the evolution of nitrous acid fumes. An orange-yellow-coloured solution is formed, which, in a few days, assumes a golden-yellow tint.
4. Sulphuric acid dissolves it, changing it to a reddish-brown colour, changed to violet by bromine vapour.
5. Hydrochloric acid with it at first forms a yellow solution, which, when heated, changes to a bright-green colour.

The physiological test may be employed by injecting a solution of a carefully prepared extract of the contents of the stomach or vomited matters, under the skin of a frog, dog, or rabbit.

TOBACCO.

The consumption of Tobacco, *Nicotiana Tobaccum (N. O. Solanaceæ)*, has greatly increased of late years. In some countries, its use was prohibited by stringent

laws. In Russia, amputation of the nose was the punishment. Several Popes have excommunicated those who smoked in St Peter's at Rome; and in some parts of Switzerland it was ranked on the tables next to adultery. Amurath IV. made smoking tobacco a capital offence. Be this as it may, the moderate use of tobacco does not appear to lead to injurious results; and it is found that workmen, engaged in the manufacture of tobacco, do not suffer from any diseases other than those affecting the generality of mankind.

Nicotina—the alkaloid—is a colourless or slightly amber-coloured, oily, volatile liquid. It is to this principle that the poisonous activity of the drug is due. It differs from the other oily alkaloid, *Conia*, in appearing of a green colour when a drop is placed on the surface of white enamelled glass—conia having a *pink* colour. They both leave a greasy stain on paper. *Nicotina* has been detected by Stass' process in the tongue, stomach, lungs, and liver. A ptomaïne not unlike nicotine has been discovered.

Symptoms.—Symptoms of poisoning by tobacco are by no means uniform, and have been variously described by observers. As a type of the effects produced, the following may be noticed as occurring to the tyro after his first or second "pipe":—The pulse is primarily quickened; then follow nausea and faintness, accompanied with an intense feeling of sinking. The face is blanched, the pulse slow; perspiration stands on the forehead, and ultimately he vomits, and then gradually recovers. Cold air blowing on the face, or sponging the face with cold water, materially hastens a return to comfort. Sometimes, as in the case related by Dr Marshall Hall of a man who smoked two "pipes," nausea, vomiting, and syncope occurred, followed by stupor, stertorous breathing, general spasms, and insensibility of the pupil. After an interval of a few

hours, the above symptoms again returned, but from which the patient ultimately recovered. Death has resulted as a sequence to excessive smoking. Gruelin records two cases—one from seventeen, the other from eighteen pipes smoked at a sitting.

The filthy habit of snuff-taking has also been accredited with one or two deaths. Santeuil, the French poet, died in two days from the effects of snuff mixed with his wine, as a practical joke.

In Animals, the symptoms are—nausea, vomiting, purging, convulsions, stupor, and death. The heart becomes paralysed. One drop of the empyreumatic oil on the tongue of a cat killed it in two minutes, the animal dying in convulsions.

Post-mortem Appearances.—These are by no means uniform or characteristic. If much vomiting precedes death, the vessels of the brain may be engorged with blood. Inflammation of the stomach and intestines is also present in some cases.

Fatal Period.—The symptoms soon make their appearance, and death has occurred in three-quarters of an hour, or even less.

Fatal Dose.—Half a drachm.

As an enema, tobacco should be used with extreme care.

Analysis.—The alkaloid obtained by the process of Stass, and mixed with water, may have the following tests applied:—

1. Chloride of platinum gives an orange-yellow crystalline precipitate.
2. Corrosive sublimate, a white precipitate.
3. Arsenio-nitrate of silver, a yellow precipitate.

Treatment.—Promote vomiting, cold water douches, and stimulants.

Lobelia.

Lobelia inflata. Nat. Ord. Lobeliaceæ.

Lobelia, or Indian Tobacco, is extensively employed in North America in the treatment of asthma. The plant is officinal in the British Pharmacopœia, of which there are two preparations—a simple and an ethereal tincture. In small doses, it possesses expectorant properties.

Symptoms. — Nausea, vomiting, giddiness, cold clammy sweats, and great depression. The pulse becomes irregular, and very feeble. Taken together, the symptoms are not unlike those produced by tobacco.

Fatal Period.—One to two days, or more.

Fatal Dose.—One drachm of the powder.

Treatment. — The same as recommended under Tobacco.

Veratria.

The alkaloid *Veratria* is obtained from the dried fruit of *Asagræa officinalis (N. O. Melanthaceæ).*

The alkaloid is in the form of a white amorphous powder, bitter and acrid to the taste. It acts as a powerful errhine, causing violent sneezing. Insoluble in water, it is readily dissolved by alcohol, ether, and chloroform. When gently heated on a plate with strong sulphuric acid, it first turns yellow, then crimson. Veratria is entirely dissipated by heat.

Two grains of the alkaloid killed a cat in one minute; a dog being destroyed in two hours by a dose of three grains. The one-sixteenth of a grain (?) of Veratria in a pill caused alarming symptoms in an adult woman, for whom it was ordered by a medical man.

The *Symptoms* and *Post-mortem Appearances* in a man are the same as in poisoning by any of the vegetable irritants, accompanied with marked symptoms of cardiac depression.

Treatment.—Stomach-pump, and emetics. Astringent infusions should be given, and alcohol and opium administered if the condition of the patient seems to require them.

HYDROCYANIC ACID.

Deaths by hydrocyanic acid are more numerous than those occasioned by any other poison, except opium and its preparations. Hydrocyanic acid is a compound of cyanogen and hydrogen. It was first obtained by Scheele in 1782, but it was not until 1815 that Gay Lussac pointed out its real nature. Anhydrous hydrocyanic acid may be obtained by passing over cyanide of mercury, gently heated, a stream of dry sulphuretted hydrogen. It is now made by mixing ferro-cyanide of potassium with dilute sulphuric acid, and applying heat, when the acid is distilled over and collected in a cooled receiver.

Dilute hydrocyanic acid, the only important form of the acid in a toxicological point, is a colourless, feebly acid liquid, with a peculiar odour, like that of bitter almonds or peach kernels (specific gravity, 0·997). The Pharmacopœial acid contains about two per cent. of anhydrous acid; that of Scheele about four per cent. According to Taylor, however, the percentage of the acid varies from 1·3 to 6·5 per cent. Taking into consideration the smallness of the dose, and the shortness of the time before death occurs, it is the most deadly of all known poisons. Prussic acid is not regarded as a cumulative poison—that is, it does not gradually accumulate in the body and then break out with dangerous or fatal violence.

Symptoms.—These will be more or less modified by the quantity of the dose, and in some cases closely resemble an attack of epilepsy. In most cases, the symptoms of poisoning are seldom delayed beyond *one* or *two* minutes; and if the dose be large, the symptoms of poisoning may come on while the person is drinking. Giddiness, followed with almost complete insensibility, mark the accession of the symptoms. The eyes are fixed, staring, and glassy; the pupils are dilated, and insensible to light. The muscles of the extremities are relaxed, and the limbs flaccid. A white or bloody froth surrounds the mouth, and the jaw is fixed. The surface of the body is cold and clammy to the touch; the respiration is sometimes long-drawn and spasmodic: and the pulse so reduced as to be almost imperceptible. The breathing is sometimes *stertorous* in character. This is an important fact; for, in ignorance of the occasional presence of this symptom, it was argued that Walter Palmer, whose breathing was stertorous, died of apoplexy, and not from prussic acid as was alleged. When the dose is small (between twenty and thirty drops of the dilute acid), the patient complains of nausea, giddiness, and a feeling of constriction round the head. The mind is confused, the pulse hurried, and the breathing irregular. Salivation may also be present. Tetanic spasms and involuntary evacuations precede the fatal termination. When the dose is from ten to twenty drops, the patient complains of nausea, giddiness, and a feeling of impending suffocation. These symptoms under treatment may soon pass off, or leave the patient more or less confused and listless. In most cases, where the dose is very large, death takes place suddenly, without convulsions; but the period of death does not appear to be as short in man as in the lower animals.

External Application.—Applied to the unbroken skin, prussic acid does not appear to have caused any

alarming symptoms; but it should be used with the utmost caution where the skin is at all abraded or ulcerated.

Post-mortem Appearances.—In making an inspection, care should be taken; for, if the dose be large, the vapour from the corpse on opening it has been known to produce giddiness and fainting. Externally, the skin is pale, livid, or of a violet colour. The hands are clenched, and the nails blue. The jaws are firmly set, and there is usually some froth round the mouth. The internal organs are greatly congested, and the venous system gorged with fluid dark-coloured blood. The stomach and intestines are sometimes inflamed, but in many cases they present no material alteration in colour.

The appearances, when only a small dose has been taken, are not unlike those of asphyxia. The detection of the odour of hydrocyanic acid in the body is of importance; but this may be absent from the following causes:—

1. Smallness of the quantity of the acid present.
2. Volatilisation from exposure of the corpse to the air.
3. The smallness of the dose, and its absence, the result of absorption and elimination, if death has not rapidly taken place.
4. The amount of dilution of the poison.
5. Concealed by other odorous substances.

In some cases, the smell may be detected in the stomach seven or eight days after death. The viscera should, in all cases of suspected poisoning, be placed in a glass-stoppered jar, the stopper covered by bladder and tin foil. Hydrocyanic acid is so volatile that, unless the greatest care be taken, all traces of it may vanish; and thus the guilty person may be allowed to escape.

Fatal Period.—From a few seconds to as many minutes. Under active treatment, if a patient survive forty minutes, he will generally recover.

Fatal Dose.—About forty-five minims of the dilute acid of the Pharmacopœia. This contains about one minim of the anhydrous acid. Recovery has, however, taken place even after comparatively large doses. The strength and age of the individual, and also the emptiness or fulness of the stomach at the time the poison is swallowed, will materially affect the issue.

Experiments on Animals.

Numerous experiments on animals have been made to ascertain the rapidity with which prussic acid kills. The late Sir R. Christison found that three drops projected into the eye acted on a cat in twenty seconds, and killed it in twenty more. The same quantity dropped on a fresh wound in the loins acted in forty-five, and proved fatal in one hundred and five seconds. In the cases where death did not occur so rapidly, there were regular fits of violent tetanus ; but in the very rapid cases, the animals perished, just as the fit was ushered in, with retraction of the head. In rabbits opisthotonos, in cats emprosthotonos, were the chief tetanic symptoms.

As a proof that the acid acts equally on the brain and spinal cord, may be noticed the presence of coma and tetanus in some cases of poisoning by this substance.

In the experiments on animals certain effects were noticed, which are as follows :—

Expulsion of the Fæces and Urine.—In some cases only the fæces, in others the urine alone, was involuntarily expelled ; and in some other cases neither the one nor the other was present.

The Shriek or Cry.—This cry, though a common, is by no means a constant symptom.

Convulsions.—These are sometimes present.

Acts of Volition.—Only slight acts are possible ; in the case of one of the dogs experimented on by Mr Nunneley, the animal "went down, came up, and then went down again the whole flight of a steep, winding staircase."

The *Post-mortem Appearances* were not well marked in the animals subjected to experiment. In chronic cases, Mr Nunneley states that both sides of the heart were distended with black blood. The pure acid is stated to completely destroy the irritability of the heart and voluntary muscles, galvanism producing no effect whatever. "In eight experiments on cats and rabbits with the pure acid, the heart contracted spontaneously, as well as under stimuli, for some

time after death, except in the instance of the rabbit killed with twenty-five grains, and one of the cats killed by three drops applied to the tongue. In the last two the pulsation of the heart ceased with the short fit of tetanus which preceded death ; and in the rabbit, whose chest was laid open instantly after death, the heart was gorged, and its irritability utterly extinct."

Treatment.—The treatment of poisoning by prussic acid is now to be considered. As part of the general treatment, the stomach-pump should be at once employed, and the stomach emptied and then washed out with water.

Ammonia.—The use of this substance was first advocated by Mr John Murray of London, and is no doubt a valuable remedy if given early. Care should be taken that the mucous membrane of the air passages and alimentary canal be not inflamed by using too strong a solution.

Chlorine.—Recommended by Riauz in 1822. Water impregnated with the vapour of chlorine may be given internally, and the gas may be breathed under proper precautions.

Cold Affusion.—First proposed by Dr Herbst of Göttingen. Its success is most to be looked for when it is employed before the convulsive stage of the poisoning is over. The cold water should be poured on the head and down the spine.

Bleeding from the Jugular Vein.—In one case treated by Magendie, bleeding from the jugular vein was attended with success.

Chemical Antidotes.—The administration of a solution of carbonate of potash, followed by a solution of the mixed sulphates of iron, has been suggested. The formation of Prussian blue is the result. The only objection to this treatment is, that prussic acid is so rapidly absorbed that death may result from the already absorbed acid before the antidote can be given.

DETECTION OE HYDROCYANIC ACID IN CASES OF POISONING.

The "Vapour Tests" are those most readily applied to organic mixtures; but in some cases it may be necessary to make a distillation of the suspected substance, in order to isolate the poison.

The first point to be noticed is, whether any *odour* of the the acid can be perceived in the substance under examination. In any case, the contents of the stomach or finely-divided tissues should be mixed with water, and examined as to the reaction with test paper. If the mixture be found to be *alkaline*, it must be neutralised by the addition of tartaric acid; if, on the contrary, it be *acid*, carbonate of soda must be carefully added to neutralisation. A state of neutrality is always necessary previous to distillation, for the following reasons:—

An *alkaline* state of the liquid would, on the one hand, prevent, or, at all events, retard, the evolution of the hydrocyanic acid; whilst, on the other, the existence of any *free acid* would decompose any cyanide which might be present, and thus give rise to an evolution of hydrocyanic acid not existing as such in the mixture.

The organic mixture is then placed in a flask, and the contents distilled at as low a temperature as possible by the aid of a water bath.

Should hydrocyanic be present, the distillate will yield all the characteristic reactions of the dilute acid. Nitrate of silver will give a curdy-white precipitate, insoluble in cold but soluble in boiling nitric acid. A portion of the precipitate, on the addition of some liquor potassæ, hydrochloric acid, and sulphate of iron, forms Prussian blue. In this test, which may be taken as quite conclusive, the hydrochloric acid decomposes the cyanide of silver; and on the addition of the sulphate of iron, Prussian blue is formed.

If a portion of the dry precipitate formed by the nitrate of silver be heated in a test tube, cyanogen gas will be evolved, known by its characteristic odour of peach blossoms, and by its burning at the mouth of the tube with a rose-coloured flame.

Vapour Tests.—There are three tests for the presence of hydrocyanic acid when present in organic mixtures, which have the advantage of being applicable without the addition of anything extraneous to the mixture to be tested. They are all dependant on the volatile nature of hydrocyanic acid, and may be applied as follows, the suspected mixture being divided into three portions :—

1. Iron or Prussian Blue Test.—The liquid mixture to be tested is placed in a small beaker glass, and covered with a glass plate, the centre of which is smeared with a mixture of potash and proto-sulphate of iron. The whole is now left undisturbed for some time. The glass is eventually removed, and the mixture of potash and iron treated with hydrochloric acid, which, should hydrocyanic acid be present, will cause the development of Prussian blue.

2. Sulphur Test, or Liebig's Test.—A second portion of the original mixture is placed in a beaker, and a watch-glass containing a few drops of bisulphide of ammonium is suspended over the liquid, the mouth of the beaker being closed. A short time is allowed to elapse; the watch-glass is then removed, and its contents evaporated to dryness at a low temperature. A blood-red colour is developed on the addition of a little perchloride of iron to the *dry* residue. This effect is due to the absorption of the hydrocyanic acid vapour by the bisulphide of ammonium—sulphocyanide of ammonium being formed, which, on the addition of perchloride of iron, gives the blood-red colour of the sulphocyanide of iron, which is bleached by corrosive sublimate.

3. Silver Test.—This is the most successful of the vapour tests, a single apple pip yielding all the reactions. If a watch-glass containing a few drops of nitrate of silver solution be suspended in a beaker (as in 2), the silver solution will become white and opaque, from the formation of cyanide of silver. The cyanide as formed, treated with hydrochloric acid, liquor potassæ, and sulphate of iron, will give Prussian blue.

The Quantitative Analysis.—Use the precipitate of cyanide of silver, 100 grains being equal to 20·33 of pure anhydrous acid.

The following plants contain prussic acid, and are therefore more or less poisonous in proportion to the quantity of the acid which they severally contain :—

Nat. Ord. Rosaceæ.

Amygdalus Communis.—The Almond and its varieties.
Prunus Domestica.—The Plum and its varieties.
Cerasus.—The Cherry and its varieties.
Pyrus Aria, or White Bean Tree.—The seeds are poisonous.

Nat. Ord. Euphorbiaceæ.

Jatropha Manihot, or Bitter Cassava.

BITTER ALMONDS.

The essential oil of bitter almonds is very poisonous. "The oil does not, like common essential oils, exist ready formed in the almond, but it is only produced when the almond pulp comes in contact with water. It cannot be separated by any process whatever from the almond without the co-operation of water—neither, for example, by pressing out the fixed oil, nor by the action of ether, nor by the action of absolute alcohol. After the almond is exhausted by ether, the remaining pulp gives the essential oil as soon as it is moistened; but if it is also exhausted by alcohol, the essential oil is entirely lost. The reason is, that alcohol dissolves out a

peculiar crystalline principle named *Amygdalin*, which, with the co-operation of water, forms the essential oil by reacting on a variety of the albuminous principle in the almond, called *Emulsin*, or *Synaptase*."

The essential oil of bitter almonds may contain from 6·0 to 14·33 per cent. of hydrocyanic acid. Deaths from the incautious use of this oil for flavouring articles of confectionery are not infrequent. As the flavour is not in the least injured, it has been suggested to subject the oil to repeated distillation with caustic potassa, by which means the oil is purified from prussic acid.

SYMPTOMS.

In Man.—Nausea, vomiting, and diarrhœa, due to gastric irritation, have occurred when the dose has been small, as is the case when confectionery owes its flavour to the use of the essential oil. Idiosyncrasy may have something to do with these effects, for cases are on record where a single almond has produced a state resembling intoxication, followed by an eruption not unlike urticaria or nettle-rash. Taken in large doses, the symptoms produced are identical with those described under poisoning by prussic acid. The breath is usually strongly impregnated with the odour of bitter almonds.

In Animals.—Vomiting, trembling, weakness, paralysis, tetanic convulsions, and coma.

Post-mortem Appearances.—These are identical with those seen in poisoning by the pure acid.

Fatal Dose.—The essential oil is from four to eight times as strong as the acid of the Pharmacopœia, From twenty to thirty drops have proved fatal. Death may take place in half-an-hour or less.

Treatment.—The same as that recommended under Prussic Acid,

CHERRY-LAUREL.

The Cherry-laurel, *Prunus Lauro-cerasus*—the leaves of which have been used for flavouring custards, etc.,—contains prussic acid, and is therefore poisonous.

In the British Pharmacopœia there is an *Aqua Lauro-cerasi*—laurel water—prepared from the leaves. It should be used with extreme caution, as the amount of hydrocyanic acid contained in the leaves is uncertain. Death has frequently resulted from its use. The most important case, however, is that of Sir T. Broughton. His mother, who gave him his usual draught on the morning of his death, observed that it had a strong smell of bitter almonds. Two minutes after he took it she observed a rattling or gurgling in his stomach; in ten minutes more he seemed inclined to dose; and five minutes afterwards she found him quite insensible, with the eyes fixed upwards, the teeth locked, froth running out of his mouth, and a great heaving at his stomach, and gurgling in his throat. He died within half-an-hour after swallowing the draught. No light was thrown on the case by the carelessly conducted *post-mortem;* but the suddenness of his death, the improbability of apoplexy occurring at so early an age, and the odour of bitter almonds observed by his mother, pointed out clearly enough the true cause of death.

ACONITE.

All parts of this plant, the *Aconitum Napellus (N. O. Ranunculaceæ)*, are poisonous. The poisonous properties depend upon the presence of an alkaloid—*Aconita*—chiefly found in the root.

Poisoning by the alkaloid has lately come before the public mind in the case of Dr Lamson, executed for the murder of his brother-in-law. The symptoms noticed in that case were very much as detailed below. When any

part of the plant is chewed, a sensation of tingling is experienced in the mouth, and burning in the throat. Many of the aconites are, however, inert. The root, having been taken by mistake for horse-radish, has led to several cases of accidental poisoning.

ACONITE.	HORSE-RADISH.
General Characteristics. — Root conical; dark-brown externally, and with numerous twisted rootlets; internally, the colour is whitish.	*General Characteristics.* — Root cylindrical, of nearly the same thickness down its whole length. Externally, buff-coloured; internally, white.
Taste. — Produces a tingling and numbing sensation in the mouth.	*Taste.*—Sweet and pungent.

SYMPTOMS.

In Man.—The patient complains, within a short time after the poison is taken, of dryness of the throat, accompanied with tingling and numbness of the mouth and tongue. He then complains of nausea, vomiting, pain in the epigastrium, and distressing dyspnœa, of a sensation of formication or tingling, with numbness in his face and limbs, which appear to him heavy and enlarged. In attempting to walk he staggers, his limbs losing their power of supporting his body. He becomes giddy, his pupils dilated, and his sight and hearing imperfect; but he is seldom unconscious till near death. His pulse irregular, gradually becomes weaker, and at last almost imperceptible; his skin cold and clammy; his features pale and bloodless; and his mind clear: then suddenly he dies, in some cases from shock, in others from asphyxia; or he may die from syncope, especially after some exertion.

In Animals.—Weakness of the limbs and staggering, the respiration slow and laboured, loss of sensation, paralysis, dimness of vision, increasing difficulty in breathing, *convulsion*, and death by *asphyxia*.

Delirium is present in some cases, and dilatation of the pupil has also been noticed. In a case recorded in the "British Medical Journal," vol. i., 1877, page 258, two ounces of the tincture of aconite were drunk in mistake for *Succus Lemonis;* recovery took place, but not before alarming symptoms had taken place, and death at one time appeared imminent.

Post-mortem Appearances. — General venous congestion. The brain and its membranes are, in most cases, found congested and the stomach and intestines inflamed.

Fatal Period.—The symptoms may come on immediately, or may be delayed for an hour or two. In the case mentioned in the "British Medical Journal" the patient walked about five miles after swallowing two ounces of the tincture, which he drank at 11 o'clock, returning home at 2.30 P.M. An excise officer, who died in about four hours, was able to walk from the Custom House over London Bridge. Death has taken place in so short a time as one hour and a quarter.

Fatal Dose.—About four grains of the extract, and one drachm of the tincture. Much will depend upon the amount of the alkaloid present. One drachm of the scraped root is said to have proved fatal.

Chemical Analysis and Tests.—The alkaloid must be isolated from the contents of the stomach by the process of Stass. The physiological test consists in placing a small portion of the extract, or the alkaloid so obtained, on the tongue or lip, and noting if tingling be produced. To the pure alkaloid, nitric acid added produces no change of colour. Officinal phosphoric acid added, and the mixture carefully evaporated, a violet colour is produced.

Treatment.—Emetics, castor-oil, and animal charcoal should be given. The administration of digitalis in aconite poisoning has been attended with the most

happy results. (See "British Medical Journal," 11th December 1872.) The drug may be given hypodermically as an antidote. Stimulants will be required; and friction down the spine, together with galvanism and artificial respiration, may be tried.

Synopsis of the Action of Aconite.

1. *On Nervous System.*—Giddiness, numbness, and tingling in the limbs is a primary effect, followed by gradually increasing paralysis of the muscles, and insensibility of the surface of the body to pinching and pricking. Dr Fleming asserts that it produces a *powerful sedative effect on the nervous system.* At any rate, it now seems to be proved that aconite paralyses the sensory nerves, commencing at their peripheral endings.

2. *On Vascular System.*—Extreme depression of the circulation is produced by doses large enough to cause death. The pulse may become imperceptible at the wrist. In medicinal doses, aconite lowers the heart's action; in poisonous doses, fatal syncope.

3. *On Digestive System.*—Some have denied the irritant action of aconite on the alimentary canal, but Sir R. Christison states that he was deterred from the use of aconite "by two patients being attacked with severe vomiting, griping, and diarrhœa."

CEREBRAL.

The symptom most characteristic of these poisons is the marked anæsthesia which they produce when their vapours are inhaled. The hydrate of chloral, though placed under the above heading, is more closely allied in its action to opium than to ether or to chloroform.

ETHER.

Ether, when taken in its liquid form, produces symptoms and *post-mortem* appearances not unlike those caused by alcohol.

Fatal Dose.—No death having been recorded, the fatal dose of this substance is unknown.

Ether Vapour.—The vapour of ether has caused death; the fatality from this source having increased of late years owing to the employment of ether as an anæsthetic. Entering the blood through the lungs, it acts with great rapidity, a state of lethargy being quickly induced.

The early symptoms are noticed in a modification of respiration, the breathing becoming slow, prolonged, and stertorous. The face is pale, the lips bluish, and the surface of the body cold and exsanguine. The pulse, at first quickened, becomes slower, as the inhalation of the vapour is continued. The pupils are dilated, and the eyes glassy and fixed. The voluntary muscles of the body become flabby and relaxed; the patient still, however, having the power to move the limbs. The involuntary muscles are not affected; as an instance, the uterus contracts and expels its contents with ease. If the inhalation of the vapour be pushed too far, the pulse sinks, and coma ensues, from which the patient can only with difficulty be aroused; but if in an early stage the ether be discontinued, the patient rapidly regains conciousness, due to the rapid elimination of the ether by the lungs. A marked peculiarity in this form of poisoning is the complete anæsthesia or paralysis of the nerves of sensation.

Post-mortem Appearances. These are chiefly found in the brain and lungs, which in most cases are greatly congested. The cavities of the heart have been found full of dark-coloured liquid blood. A marked effect

noticed in poisoning by ether, is the congestion of the vessels of the upper portion of the spinal cord. The liver, kidneys, and spleen are sometimes congested.

Treatment.—When the pulse becomes weak, and the breathing laboured and stertorous, the inhalation should be discontinued, and cold water dashed in the face—free ventilation being also allowed. Galvanism and artificial respiration should also be tried.

Analysis.—The contents of the stomach and tissues must be treated and distilled, as described under Alcohol.

Tests :—

1. The vapour passed into a solution of bichromate of potash, and sulphuric acid added, gives the reactions of alcohol.
2. The vapour burns with a smoky flame, depositing carbon on any cool surface placed above the flame.
3. It is but sparingly soluble in water, on which liquid it floats.

CHLOROFORM.

The effects produced by chloroform when swallowed are not unlike those occasioned by alcohol. Four ounces have been taken without causing death ; it is, therefore, not an active poison in this form.

Chloroform Vapour.—The symptoms occasioned by chloroform when inhaled are not unlike those caused by ether, with this exception, that insensibility and general relaxation of the muscles are more rapidly produced. A Mrs Bartlett was recently tried for poisoning her husband by the administration of chloroform. The case, which presented several interesting peculiarities, ended in an acquittal of the lady.

Post-mortem Appearances.—Congestion of the vessels of the brain, and also of the lungs, is generally found. The cavities of the heart are usually empty; but, in some cases, the right side of the heart is found distended with dark-coloured fluid blood. Congestion of the spleen, liver, and kidneys is not of infrequent occurrence.

Fatal Period and Dose.—In one or two cases where the vapour was inhaled, death took place in from one to two minutes. Thirty drops thus taken destroyed life in one minute, and even fifteen drops have proved speedily fatal. It has thus destroyed life in a smaller dose, and more rapidly, than any other known poison.

Treatment.—The same as recommended with regard to ether. M. Nelaton recommends inversion of the body, and ascribes the recovery of one patient to his suddenly lifting him up and throwing him over his shoulder with his head hanging down.

Analysis.—Dissolves camphor. Is not affected by nitric and sulphuric acids. Boils at 140° F.; and the vapour, subjected to a red-heat, is resolved into chlorine and hydrochloric acid.

Detection of Chloroform in the Blood and Tissues.

In searching for the presence of this substance in the blood or tissues, the examination should be made as speedily as possible, as chloroform seems to have a great tendency to pass into formic acid, and thus to escape recognition.

The substance to be examined should be placed in a flask, to which is adapted a glass tube bent at right angles. A piece of blue litmus paper, and another portion of paper moistened with iodide of potassium and starch paste, are inserted into the end of the glass tube. The flask and its contents should now be placed in a water bath heated to a temperature of 161° F. (72° C.), and a portion of the glass tube just past the

bend heated to redness. Any chloroform vapour evolved from the contents of the flask is decomposed during its passage through the heated glass tube into free chlorine and hydrochloric acid, the presence of the former being indicated by the starch paper becoming blue; while at the same time the reddening of the litmus paper reveals the presence of the acid. As a further corroboration, the exit-tube may be made to dip into nitrate of silver solution, when a precipitate of the curdy-white chloride of silver will take place, insoluble in nitric acid, but dissolving on the addition of ammonia. Every 100 parts of chloride of silver formed, equals 27·758 of chloroform.

Carbon Bisulphide.

This substance is largely used in certain industries, as it dissolves oils, fats, caoutchouc, gutta percha, etc. It boils at 47°, is very inflammable, burns with a blue flame, evolving sulphur dioxide. The odour, when this substance is impure, is very disagreeable. If taken internally, it produces an intense burning sensation in the throat, headache, and giddiness. In chronic poisoning from the vapour in manufactories where it is used, there appears to be two stages—one of excitement, and one of depression. In the former, there is more or less persistent headache, irritability of temper, tinnitus aurium, and even mania; in the latter, anæsthesia of the skin, even affecting the mucous membranes, patients complaining that their tongues feel as if tied in a cloth. Paralysis of the limbs has been noted in prolonged cases of chronic poisoning. The *post-mortem* appearances do not differ much from those found after death from the inhalation of chloroform. Carbon bisulphide may be separated from organic liquids by distillation, and detected by its odour, boiling point, and by a black precipitate of sulphide of lead when heated with nitrate of lead and potash.

CHLORAL HYDRATE.

This substance is prepared by acting on alcohol by chlorine. It has only been introduced to the medical profession since the year 1869, and, owing to its indiscriminate use, many fatal cases have been recorded. Care should be taken when large doses are given not to repeat them too quickly, as there appears to be a tendency to accumulation, and sudden and dangerous action of the drug.

Symptoms.—Chloral, in moderate doses, acts on the brain as a powerful hypnotic, the early symptoms being gradual drowsiness, followed by deep sleep. With a dose of about 30 grains, the patient can, however, by walking about, ward off sleep. In large doses the narcosis becomes completely uncontrollable, and the poison then acts as a depressant to the basal ganglia of the brain, and on the spinal cord; and, as a result, there is weakness of the heart's action, with ultimate diastolic arrest, slowing of the respiratory movements, and general muscular weakness, with some anæsthesia. Under these circumstances the patient has all the appearance of a drunken person, the face is flushed, and the deep sleep may pass imperceptibly into death without any marked change. In some cases delirium precedes the condition of sleep. The pulse in some cases is quickened, and the face flushed; but, in other cases, the pulse becomes slow and almost imperceptible, the heart being ultimately arrested in diastole. In these cases the face is pale, and the breathing performed at long intervals. The motor paralysis present, when a poisonous dose is taken, is due to the action of the drug on the spine, and not on the nerves. During the sleep produced by chloral, the pupils are contracted, but dilate on the person awakening. In a case described by Dr Levinstein, and reported in the "Lancet," 21st February 1874, the

patient took six drachms with intent to commit suicide. The face was at first flushed, the veins swollen, and the pulse 160 per minute; he then became livid, the pupils contracted, and at times the circulation appeared to be entirely arrested. The temperature varied from 32·9° C. to 38·7° C (89·6° F., 100·4° F.) This case recovered under treatment by the subcutaneous injections of strychnia (·03 to ·04 grains), and the use of Faradisation in thirty-two hours after the poison had been taken. Chronic chloral poisoning, "chloral drinking" has unfortunately become far too common of late years, in which the mental faculties suffer severely, so that in our asylums, cases of mania and melancholia are rightly (or wrongly) attributed to the habit. A peculiar eruption, not unlike that produced by shell-fish, and followed by desquamation — and which I believe I was the first to describe—sometimes occurs when this substance has been given for some time in medicinal doses.

Post-mortem Appearances.—These are not unlike those of asphyxia, the vessels of the brain being engorged, and the ventricles containing an abnormal quantity of fluid. The mucous membrane of the larynx may be injected, and in some cases œdematous. The right side of the heart is engorged and the left empty, together with congestion of the lungs.

Treatment.—The treatment consists in the use of galvanism, friction, mustard-plasters to the calves of the legs, artificial respiration, and the hypodermic injection of a solution of nitrate of strychnia or injection of atropia. The warmth of the body must be carefully maintained in all cases by suitable external applications.

Fatal Dose.—The fatal dose cannot be accurately stated, but children, as in the case of belladonna, are said to bear the drug better than adults. A child a year old died in ten hours from a dose of three grains.

As a rule, any quantity over two drachms may be considered a dangerous, if not, a fatal dose, although recovery has been stated to have occurred after one ounce. Dr Richardson considers 120 grains, distributed over twenty-four hours, as a safe dose for an adult. Death may take place suddenly, or after the lapse of several hours.

Analysis.—Chloral is not inflammable. If potash be added to a boiling solution of chloral, it becomes decomposed with effervescence into chloroform and formic acid, and formate of potash is formed. Boiled with chloride of gold or nitrate of silver, the metals are precipitated on the addition of potash or a little ammonia. This test and the next may be applied to chloral in a cup or other vessel. Ammonium sulphide added to a neutral solution of chloral, produces a yellow solution or precipitate like antimony; but on the addition of a few drops of acid the antimony falls as an orange-yellow precipitate, the chloral as a light-white precipitate of sulphur. A salt of copper is decomposed by chloral in a manner not unlike grape sugar.

Detection in the Tissues, etc.—Being decomposed in the blood into chloroform, it can only be detected by the means already described for the detection of that substance, the liquid being first rendered alkaline with potash. (See page 390.)

NEURAL.

CONIUM.

The common or Spotted Hemlock, *Conium Maculatum (N. O. Umbelliferæ)*, is indigenous. It must be distinguished from the *Myrrhis Temulenta*, another indigenous, umbelliferous plant, which has also a spotted stem, but which is covered with hairs—the

stem of the hemlock being smooth. Several cases of poisoning have occurred, hemlock having been mistaken for parsley, fennel, asparagus, and parsnip. The leaves of the plant have a peculiar mousy odour, which is intensified when they are rubbed in a mortar with some caustic potash. The poisonous properties reside in an alkaloid, *Conia.* The activity of the plant appears to depend upon the time of the year when it is gathered, being most powerful in May. The ready decomposition of the alkaloid by heat or age renders the extract of conium a very uncertain preparation, the conia being converted into an inert resinoid matter.

Conia.—The alkaloid is a colourless volatile oil, lighter than water, with an odour of mice. It is strongly alkaline, soluble in diluted acid, but its salts have not yet been crystallised. It has been suggested that a ptomaïne not unlike conia may be formed in the body by the combination of one molecule of butyric acid and one molecule of ammonia with separation of water, thus—

$$\underset{\text{Butyric Acid.}}{2\,C_4H_8O_2} + \underset{\text{Ammonia.}}{NH_3} - 2\,H_2O = \underset{\text{Conia.}}{C_8H_{15}N}$$

Conia is a deadly poison, killing all animals, death resulting from asphyxia. Neutralised with an acid, its activity is increased, and it becomes more soluble in water. Almost instant death resulted in a dog from injecting two grains of conia, neutralised with hydrochloric acid, into the femoral vein.

SYMPTOMS.

In Man.—The symptoms in some cases resemble those of poisoning with opium ; in others, the patient complains of dryness and constriction of the throat, and drowsiness. There is dilatation of the pupil, with closure of the eyes or ptosis, and loss of power in the

muscles of the extremities, so that the patient falls on attempting to walk. The paralysis does not appear to be due to any direct influence upon the muscles, but upon the motor nerves, and especially on their extreme peripheral ends, and in this differs from Calabar bean, which acts on the spinal cord. Gradual loss of power in the respiratory muscles is the cause of death. Giddiness, coma, and convulsions were the typical symptoms of two cases of accidental poisoning recorded by Dr Watson.

In Animals.—" Palsy, first of the voluntary muscles, next of the chest, lastly of the diaphragm—asphyxia, in short, from paralysis, without insensibility, and with slight occasional twitches only of the limbs; and the heart was always found contracting vigorously for a long time after death." (Christison.)

Post-mortem Appearances.—Congestion of the vessels of the brain and lungs. The blood is very fluid, and of a dark colour, the fluidity due probably to the mode of death—slowly induced asphxia. There may be some redness of the mucous membrane of the alimentary canal.

Fatal Period.—The symptoms may come on in from ten minutes to an hour, or more, after the poison has been taken. Death usually takes place in about four hours.

Fatal Dose.—Uncertain. Thirty grains of the extract carefully prepared killed a rabbit in five minutes. A single drop of conia dropped into the eye of a rabbit killed it in nine minutes.

Treatment.—Emetics, stomach pump, castor-oil, followed by ammonia and other diffusible stimulants.

CALABAR BEAN.

A strong emulsion of Calabar bean, *Physostigma Venenosum* (*N. O. Leguminosæ*), is used on the

Western Coast of Africa as a test of innocence in cases of suspected witchcraft. In 1864 some children in Liverpool were poisoned by eating some of these beans, which had been swept out of a ship from Africa on to a heap of rubbish.

Symptoms.—Vomiting, giddiness, irregular action of the heart. The mental faculties are unaffected. The eyes are bright and the pupils *contracted;* in which latter it differs most strikingly from atropia, hyoscyamia, and datura, where dilatation of the pupil is the rule. The late Sir R. Christison considered that its primary action is on the heart, causing paralysis of that organ, and that the insensibility and coma are only secondary. Dr Harley considers that it is not a cardiac, but a respiratory poison. Later experiments have shown that the paralysis produced is due to the action of the drug on the spinal cord and not on the nerve trunks. It appears also that death is due to a failure of the respiration, for the heart in animals has been found still beating for one and a half hours after death. The contraction of the pupil, when locally applied, is probably brought about by its paralytic action on the peripheral sympathetic nerve fibres of the iris; and it is stated that when very large doses of physostigmin are given, the pupils dilate, pointing to oculo-motor palsy. A few drops of the extract placed in the eye cause powerful contraction of the pupil.

Analysis.—The physiological test is the effect on the pupil. Bromine dissolved in water is stated by Dragendorff to produce a red colour with the Calabar bean.

EXCITOMOTORY.

Nux Vomica. Strychnia.

Some of the most poisonous known plants belong to the genus *Strychnos* (*N.O. Loganiaceæ*).

The Java poison, *Upas Tieuté*, is a watery extract of S. Tieuté; the basis of the poison used in Guiana, and known as Wourali, Ourari, Urari, or Curare, is the juice of S. Toxifera. S. Nux Vomica, the Koochla tree, produces the nux vomica seeds of commerce; and the bark of the tree has been accidentally substituted for cusparia, or angustura bark, hence it is known as *false angustura* bark. The substitution is attended with considerable risk, on account of the strychnia which the false bark contains. It may be known by its being quilled, externally covered with white lichenous spots, and the internal surface becoming *blood-red* when touched with nitric acid. This reaction, which depends upon the presence of an alkaloid, brucia, *does not* occur when true angustura bark is thus treated.

NUX VOMICA.

The Seeds of S. Nux Vomica.

The British Pharmacopœia contains an extract and a tincture. The alkaloid strychnia is the active principle of the seeds and other parts of the plant. Another alkaloid, brucia, is also found, and is poisonous.

The symptoms and *post-mortem* appearances and treatment will be detailed under the head of Strychnia. The brown powder of the seeds may, in some cases, be seen adhering to the mucous membrane of the stomach.

STRYCHNIA.

Recently a medical man, Dr Neil Cream, was executed for administering strychnia in gelatine capsules to a number of prostitutes in London, and thus causing their death.

Symptoms.—Should the poison be in solution, the patient complains of a hot and intensely bitter taste during swallowing. The effects of the poison depending to a great extent on the mode of adminstration, become manifest in from a few minutes to an hour, or more after it is taken. The earliest symptoms are a feeling of suffocation and great difficulty of breathing. These come on suddenly, without any premonitory warnings. Twitching of the muscles, rapidly passing into tetanic convulsions of nearly all the muscles of the body, which are simultaneously affected. The head after several jerks becomes stiffened; the neck rigid; the body curved forward, quite stiff, and resting on the back of the head and heels. The face is congested, and the countenance expresses intense anxiety; the eyes staring, the mouth open, and the lips livid. The throat is dry, the thirst great; but when an attempt is made to drink, the jaws are spasmodically closed, and a piece of the vessel may be bitten out. During the intervals of the paroxysms the intellect is usually clear, and the patient appears conscious of his danger, frequently exclaiming, "I shall die!" and he is also conscious of the accession of the paroxysms, telling those around him of their approach, and asking to be held. In the case of J. P. Cook, poisoned by Palmer, those about him tried to raise him; but he was so stiff that they found it impossible. He then said, "Turn me over," which they did, and he died in a few minutes. Intense pain is felt, due to the powerful contractions of the muscles. After the lapse of a minute or two, the spasms subside, a sudden lull takes place, during which the patient feels exhausted and his skin is bathed in sweat.

In poisoning by strychnia, the jaws are slightly, if at all, affected.

In tetanus the result of disease, the locking of the jaws is an early and a marked symptom.

As death approaches the fits become more frequent, and the patient dies from exhaustion or suffocation.

Post-mortem Appearances.—There is no characteristic appearance found after death. The blood is fluid, the heart empty, with some congestion of the membranes of the brain. Absence of all cause for so violent and sudden a death. *Rigor mortis* is prolonged for some time.

Fatal Period.—The rapidity in the accession of the symptoms and fatal termination will, to some extent, depend upon the form in which the poison is taken—*i.e.*, in solution or in pill. In most cases the symptoms appear in from three or four minutes to an hour or more, after the poison is swallowed, death following in from ten minutes to six hours.

Fatal Dose.—A quarter to half a grain; but large doses have been taken, followed by recovery.

Treatment.—Evacuation of the stomach by emetics and the stomach-pump, and then the adminstration of animal charcoal, iodide of potash, tannic acid and tea; bromide of potassium in large doses (half-an-ounce), and repeated in smaller doses; chloral, followed by diffusible stimulants.

Analysis.—The poison may fail to be detected, and this link in the scientific evidence may be wanting, as was the case in Palmer's trial. In that case the strychnia had been administered in *pills;* and when after death the stomach had been cut open, and the contents lost, there was little hope of discovering the poison. The non-discovery of the poison was made a strong point on the part of the defence, ignoring at the same time the fact that the stomach had been tampered with and the contents spilt. Death may be the direct result of a dose of strychnia, and yet it may not be detected in the dead body, even with the greatest care and when the body has not been tampered with. The alkaloid abstracted from the tissues or contents of the stomach

by Stass' process may have the following tests applied to it :—

1. Scarcely soluble in water, but readily soluble in acidulated water.

2. Intensely bitter taste.

3. Not affected by sulphuric acid ; but when a little peroxide of lead, or peroxide of manganese, or bichromate of potash, or ferri-cyanide or permanganate of potassium is added, a magnificent purple-blue colour, changing to crimson, and finally to a light-red tint is the result. Less than $\frac{1}{100000}$ part of strychnia has been stated to give this reaction.

4. The physiological test consists in introducing a small quantity of the suspected substance under the skin of a frog, and noting whether or not the animal suffers from tetanic spasms.

5. The galvanic test.—Place a solution of strychnia, say one part of strychnia in 15·000 of water, in a slight depression in a piece of platinum foil, and allow the mixture to evaporate. When dry, moisten the spot with sulphuric acid, and then connect the foil with the positive pole of a single cell of Grove's battery, and then touch the acid solution with the negative pole. A violet colour will be at once produced, remaining permanent.

Strychnia may not be found in the body, even after death from poisoning by it, for the following reasons :—

1. Smallness of the quantity taken.

2. The time which has elapsed after taking the strychnia until the symptoms commence.

3. If the careful preservation of the stomach and its contents has been overlooked.

[TABLE

THE FOLLOWING TABLE WILL ASSIST IN FORMING A DIAGNOSIS OF DEATH BY STRYCHNIA, AND THAT THE RESULT OF DISEASE :—

TETANUS FROM EXPOSURE TO COLD OR WET, OR THE RESULT OF A WOUND.	TETANUS FROM STRYCHNIA.	HYSTERIA.	EPILEPSY.	TETANUS OCCURRING DURING THE ACTION OF OTHER POISONS.
1. The presence of a wound. Symptoms have no connection with any liquid or solid swallowed.	1. Some solid or liquid taken within a short time of commencement of symptoms. Not connected with any peculiarity of constitution.	1. Connected with a peculiar constitution. Rare in males.	1. Previous history of epilepsy.	1. The presence of other symptoms of poisoning peculiar to certain poisons.
2. Gradual accession and progress of the symptoms; difficulty in swallowing; stiffness of the jaws, neck, trunk, legs, and arms. The hands not generally affected.	2. Symptoms sudden and violent. All the muscles are affected at one and the same time. Arms affected and hands clenched at the same time as the body and legs. Jaw only affected or fixed during efforts to swallow.	2. The presence of known signs of hysteria.	2. Presence of the *aura epileptica*. The tongue bitten; and insensibility lasting for some time.	*Obs.*—Arsenic, antimony, and other irritant poisons, may sometimes cause tetanic spasms; but other symptoms are present which point to the nature of the poison.
3. Curving of the spine forwards not primarily present; generally comes on after some days of previous illness.	3. Opisthotonos an early symptom, generally appearing in a few minutes	3. The spasms frequently convulsive, and alternating with stiffness of the muscles. Loss of consciousness.	3. Alternate contraction and relaxation of the muscles.	
4. Symptoms may undergo abatement, but there is no perfect intermission.	4. Intervals of complete intermission.	....	....	....
5. Death after the lapse of several hours or days. Direct injury to spinal cord may give rise to tetanus and death in a few hours. Recovery slow.	5. Death usually occurs in three hours, or even less than a quarter of an hour. Recovery in a few hours.	5. Never fatal. Recovery very rapid.	5. Seldom fatal during first attack.	....

IRRESPIRABLE GASES.

CARBONIC ACID.

1. *Circumstances which may show that it is Suicidal.*—The position of the body and the presence of one or more of the methods adopted for the generation and escape of the gas. But it must always be borne in mind, that in order to conceal a murder, the body may be placed under circumstances which point to carbonic acid poisoning. Poisoning by this gas is a favourite mode of suicide in Paris.

2. *Circumstances under which it occurs Accidentally.*—Death may result where several persons are sleeping in the same room, and the ventilation is imperfect; from the admission of the vapour of charcoal into a room from an adjoining vent; or from incautiously sleeping in a brewery close to a vat in which fermentation is going on. Many deaths have occurred from this gas, due to the incautious descent into a well; and a year ago, two men lost their lives in a deep well in Manitoba—the second in going to look after the first. It must also be borne in mind that death may result from the presence of this gas in an atmosphere which will permit the combustion of a candle. For a candle will burn in an atmosphere containing 25 per cent. of CO_2, whereas 5 per cent. will cause death. The burning of a candle is therefore no test of security from danger in an atmosphere where the presence of carbonic acid is suspected. Carbonic acid does not, as is generally supposed, sink to the lower portions of a room; and Dr Taylor, from his experiments, states "that in a small and close room persons are liable to be suffocated at all levels, from the very equal and rapid diffusion of carbonic acid during combustion."

3. *Symptoms.*—When the carbonic acid is pure, that is, unmixed with other gases, spasm of the glottis at once occurs, and the sufferer falls down insensible, and death

is almost immediate. When the gas is diluted the early symptoms are a feeling of weight and fulness in the head, accompanied with giddiness, throbbing of the temporal arteries, drowsiness, palpitation of the heart, gradually increasing insensibility, stertorous breathing, ending in death from asphyxia or apoplexy. Sometimes the victim dies convulsed, at other times a deep sleep quietly merges into death. The symptoms will, of course depend upon the quantity and purity of the gas present in the apartment.

4. *Action on the Animal Economy.*—The opinions of observers vary greatly—Berzelius maintaining that an atmosphere containing 5 per cent. was not injurious to life; Allen and Pepys, on the other hand, stating that 10 per cent. of the gas would cause death. Bernard considers that it is not poisonous, as it can be injected into the bodies of animals without injury, and that its action is purely negative; it is irrespirable in the same sense as pure hydrogen or nitrogen is—simply, therefore, causing death by suffocation. Whatever may be the true explanation of its action, it is enough for all practical purposes to know that death follows when it is breathed, even when mixed with a normal amount of oxygen.

5. *Post-mortem Appearances.*—The face may be pale and composed, or swollen and livid. The vessels of the brain are frequently greatly congested, and the heart and great vessels gorged with black fluid blood. The blood in some cases, however, is of a cherry-red colour. This may probably be due to the presence of carbonic oxide, which appears to have the power of preventing the change of arterial into venous blood, the opposite effect to that of carbonic acid. The tongue may or may not be protruded beyond the teeth; in most instances the latter is the case. Animal heat is long retained after death, and the *rigor mortis* occurs as in other forms of death.

6. *Treatment.* — Bleeding from the arm, cupping from the nape of the neck, and the employment of cold affusion to the head. The patient should be removed without delay into the open air. Artificial respiration and galvanism have been successfully employed in some cases.

7. *How the proportion of Carbonic Acid may be estimated.*—The air to be examined is drawn into a vessel capable of holding one and a half gallons, to which is added a clear solution of lime or baryta. The vessel, after being well agitated, is allowed to remain untouched for from eight to twenty-four hours. The carbonic acid is absorbed by the lime or baryta, and the difference in the causticity of the lime solution before and after it is placed in the vessel gives the amount of carbonic acid present in the air. A simple method of collecting the air in a mine is by lowering a bottle full of fine sand, so arranged that at any depth it may be turned upside down, and the sand allowed to run out, its place being taken by the air of the mine. The bottle may now be quickly drawn up, corked, and reserved for examination.

8. *How may an Apartment, a Well, or Mine be cleared of it?*—Free ventilation in the first case. In the case of a well, a basket of slaked lime may be let down; but in mines a steam fanner or a jet of steam must be blown through the mine. No one, of course, should he allowed to enter the well or mine till it has been cleared of the carbonic acid.

CARBONIC OXIDE.

This gas is formed in a variety of ways, one being the oxidation of carbon at a very high temperature in a limited supply of oxygen. It is given off by iron stoves at a red heat. It is one of the chief ingredients of the vapour of burning charcoal. It is a very powerful gas, speedily causing death by acting chiefly on the

nervous system, the symptoms being those produced by a pure narcotic. In some cases sufferers complain of intense headache, pulsation in the temples, giddiness, nausea, followed with vomiting.

The *post-mortem* signs are redness of the face, with reddish patches on different parts of the body. The blood—and this is chiefly characteristic of carbonic oxide poisoning—is cherry-red, due to a chemical compound formed by the action of the gas on the colouring matter of the blood, thus paralysing the oxygen-carrying power of the blood corpuscles. The gas is supposed to combine with the hæmoglobin forming a fixed compound, the spectroscopic examination showing the absorption band of the hæmoglobin nearer to the red end of the spectrum than under normal conditions.

The *treatment* consists in the removal of the sufferer into the fresh air, artificial respiration, venesection, and the transfusion of arterialised defibrinated blood.

To this gas is due the suffocating quality of air in which coke or charcoal is burnt. It is inodorous, hence the dangerous insiduousness with which it produces its fatal results. It is said that ·5 per cent will cause death, and even ·1 per cent is injurious. The vapours from brick kilns and "burnt ballast" heaps are injurious to health, and the owners of them may be indicted for causing a nuisance.

Water Gas.

This gas is prepared by passing steam through incandescent carbon, and is a compound of nearly equal parts of carbonic oxide and hydrogen. It owes its dangerous properties to the first named gas. When water gas, pure and simple, is supplied for heating purposes, its leakage cannot be detected as the gas possesses no odour. When used for lighting and carburetted, its escape is more readily detected by the

smell, but even then it is more dangerous than coal gas as the proportion of CO is higher. Several deaths have resulted from the use of water gas for heating and lighting purposes, and also for steel smelting in Leeds. The symptoms of poisoning are those of carbonic oxide.

Sulphuretted Hydrogen.

Sulphuretted hydrogen is a gas possessing a powerful odour of rotten eggs. It is largely used as a test for most of the metals; and its presence may be detected by filtering paper, moistened with a salt of lead, becoming black.

Symptoms.—When the gas is moderately diluted the symptoms produced are giddiness, throbbing of the temples, pain and oppression of the stomach, nausea, and vomiting; delirium and convulsions sometimes occur, together with laborious respiration and an irregular pulse. When the gas is but slightly diluted, the person becomes suddenly weak and insensible, and rapidly dies.

Post-mortem Appearances.—Fluidity and blackness of the blood, loss of muscular contractility, and a tendency to rapid putrefaction. The bronchial tubes are reddened, and the internal vascular organs may appear almost black.

Treatment.—This will consist in the immediate removal of the person into fresh air, and the administration of stimulants, together with the respiration of chlorine gas evolved from bleaching powder by the action of an acid.

Coal Gas.

Coal Gas is composed of several hydro-carbons, the chief of which is marsh gas, together with free hydrogen, carbonic oxide and carbonic acid, ammonia, hydrogen sulphide, and sulphides of carbon, which

give to it its peculiar odour. The poisonous properties of coal gas are due to the carbonic oxide, 7·5 per cent. being present in ordinary gas as supplied for illuminating purposes. It can be detected by passing the coal gas through an acid solution of cuprous chloride, which becomes black by the formation of a compound CuCOCl. A dangerous explosive compound is formed when the gas reaches the proportion of 1 in 10 of the atmosphere. Poisoning by this gas is, as a rule, accidental.

Symptoms.—Headache, nausea, vomiting, giddiness, ending in coma. Stertorous breathing is noticed in some cases. Should the sufferer be removed from the gas, the breath smells strongly of the gas. The murderer Chantrelle tried to cover his crime by admitting gas into his wife's bedroom, but the attempt failed. The pupils are, as a rule, dilated before death.

Post-mortem Appearances. — Dark colour of the blood, redness of the pulmonary tissue, and froth in the air passages. The vessels of the brain are engorged, and rose-coloured patches appear on the thighs.

Treatment.—This consists in removing the patient into the fresh air ; artificial respiration, etc.

TOXICOHÆMIC OR SEPTIC.

Under this head may be classed all those effects produced by the sting or bite of various insects and reptiles, and also by the bite of the mad dog and wolf.

No medico-legal question is likely to be raised on this subject, at least in this country, where, with the exception of the common viper or adder, all our reptiles are harmless enough.

PUBLIC HEALTH, OR MEDICAL POLICE.

In this division of the book we shall discuss the laws which affect the individual and social relations and well-being of man. For this purpose we shall hold that man, subject to certain physical and moral influences, should be regarded rather as a species than as an individual.

These influences are—

I. Purely physical or *natural.*—1. Sex. 2. Age. 3. Locality. 4. Periods. 5. Seasons. 6. Hours of the Day.

II. Moral or *disturbing.*—By the operation of this second group Man is distinguished from the Lower Animals.

I.—PURELY PHYSICAL.

1. **Sex.**—More male children die in the earlier years of infancy than female. The male births are in excess of the female. In England it appears that there are 103·5 boys for every 100 girls; in Russia, 108·91; and in France, 106·55. In Italy the proportion is greater than in other countries.

Several suggestions have been made to explain this law. Some have tried to show that, after the birth of a son, means are taken to prevent further increase in the family. Giron de Buzareignes is of opinion that employment has a governing influence, the more lusty

male reproducing his sex. Thus more males are born in the country than in towns. Bickes considers that the excess of males depends on certain physiological peculiarities of race. Hofacker and Quetelet lean to the opinion that the relative ages of the parents are the determining causes. The tables they give certainly bear out this statement, for in cases where the age of the male exceeded that of the female by eighteen years the male births were double those of the female.

As has already been stated, more males die during infancy than females, and this effect of the sexes is well pronounced in all that concerns the deaths. This mortality does not only affect the males before birth, but even during the first ten or twelve months after birth—that is to say, during the period of nursing. The ratio of deaths before birth, is as 3 to 2; during the first and second months after birth, as 4 to 3; during the fourth and fifth months, as 5 to 4; till between the eighth and ninth, the difference between the male and female deaths is almost *nil*. In Belgium, the ratio of male still-births to female is as 1·33 to 1 for the towns, and 1·70 to 1 for the country. At birth the mortality is greater in males than in females; but at two years of age the mortality is nearly the same. At the age of puberty the female mortality is in slight excess of the male; between 21 and 26 the male deaths are again in excess of the female; but between 26 and 30 they are equal. During the period of child-bearing the female deaths exceed the male in country places, but this mortality again diminishes after the catamenia have ceased. Taking the whole term of life, the female has the advantage of long life; yet, owing to the risks of child-birth, female life is not so insurable as male; but, when the period of child-bearing has passed, as an annuitant, she has an immense advantage. It is also found that congenital malformations are more common in the male than in the female, due probably to some intra-uterine forces, the exact nature of which

have not yet been determined, but which appear to act before birth. Males are more liable to diseases of the vascular system, calcification, and atheroma of the arteries, angina pectoris, and also to dangerous hæmorrhages.

2. **Age.**—The fecundity of marriages appears to be in an inverse ratio to the age of the parents. The fecundity of marriages is greatest when the husband and the wife are about the same age, or in those in which the man is older than the woman by from 1 to 6 years. The number of births is not, however, appreciably affected when the diffierence in the ages does not exceed 16 years; but the minimum of fecundity is reached when this limit is exceeded, or the man is much younger than the female.

Early marriages are generally sterile, or, when children are born, the tendency to early death is great. Fruitful marriages produce the same number of births, irrespective of age or locality, provided the age of the man is at or about 33, and that of the woman 26 years. After these ages, the number of births gradually diminishes.

The period of greatest fecundity is, therefore, at 33 years of age for the man, and 26 for the female.

In Great Britain, the average age at which marriages take place is 25 years for males, and 24 for females. The age of majority in England, according to the common law, is 21; all persons under that age are infants. Males at 14, and females at 12, may consent to marry; but they cannot marry legally, without the consent of their guardians, till they are 21 years of age. The number of marriages very sensibly diminishes over 40 years of age. The fecundity of women ceases between the ages of 45 and 50; that of men is uncertain.

Age exerts a powerful influence on the mortality, and this influence is universally acknowledged. The annual rate of infant mortality in England and Wales

in 1882 was 141 per 1000, and the average of the ten previous years was 150 per 1000. Seventeen per cent. die during the first year, and 50 per cent. under five years. Thus, of every 1000 children born, 500 die within the first five years of life. Out of 100,000 males alive at three, only 94,417 will probably be alive at ten; of females at the same age, 94,551. At the age of fifty, 59,123 males will be alive, and 65,237 females. Nine females out of 100,000 may reach the age of 100, but none of the other sex.

A large amount of the mortality among infants may be due to the ignorance of mothers as to the simplest dietetic and hygenic arrangements, and to the pernicious habit of drugging the children to keep them quiet. This system is probably more often practised by those left in charge of the children, during the absence of the mothers "at work," than by the mothers themselves.

At the age of five the mortality, which had previously been so marked, is suddenly arrested; and it is at this age that the probability of life is greatest. At puberty the maximum of viability is reached; after that period the mortality gradually increases, especially among women, when the passions become developed, and the dangers of maternity are greatest. Between sixty and sixty-five the probability of life becomes very doubtful, and the mortality is doubled every ten years.

[TABLE

TABLE SHOWING PROBABLE DURATION OF MALE AND FEMALE LIFE IN DIFFERENT COUNTRIES AT DIFFERENT AGES.

AGES.	SWEDEN.		ENGLAND.		BELGIUM.		NETHERLANDS.		BAVARIA.		GENERAL MEAN.	
	Berg.		Farr.		Quetelet.		Baumhauer.		De Herman.			
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Birth.	48	55	44	46	40	43	31	36	22	32	37	43
5 years.	54	59	54	56	53	54	51	54	53	53	53	55
10 "	50	55	51	52	49	51	49	51	50	49	50	52
15 "	45	50	47	48	46	47	44	47	46	45	46	47
20 "	41	46	43	44	42	43	40	43	41	41	41	43
25 "	37	42	39	40	38	40	37	39	38	37	38	40
30 "	33	37	25	36	34	36	33	34	34	33	34	35
35 "	29	33	31	32	30	32	29	31	30	29	30	31
40 "	25	29	27	29	26	28	25	27	26	26	26	28
45 "	22	25	23	25	22	25	22	24	22	22	22	24
50 "	18	21	20	21	18	21	18	20	18	18	18	20
55 "	15	17	16	17	15	17	15	16	15	15	15	16
60 "	12	13	13	14	12	13	12	12	12	11	12	13
65 "	9	10	10	11	10	10	9	9	9	9	9	10
70 "	7	7	8	8	7	7	7	7	7	7	7	7
75 "	5	5	6	6	5	6	5	5	5	5	5	5
80 "	3	4	4	4	4	4	3	3	3	4	3	4

3. **Locality.**—Locality exercises on man a physiological and a pathological influence, and in this connection the question of acclimatisation may arise. We may define acclimatisation as the faculty possessed by the organism to adapt itself to a climate other than the one in which it was born. Probably the power of reproducing itself under the altered conditions of its existence is the great proof of absolute naturalisation.

The first thing to be considered under this head is the effect of locality on fecundity; and on this subject the data are unfortunately very incomplete. It is stated on the authority of Villermé that in marshy districts conceptions sensibly diminish during the periods of the year when the marsh miasm is most freely given off.

The fecundity of the inhabitants of even neighbouring countries varies greatly ; thus, in England, the ratio of births to the number of inhabitants is 1 to 35·0 ; in France, 1 to 31·6 ; Sweden, 1 to 27 ; and in Prussia, 1 to 23·3.

It is stated that "the places which produce annually the greatest number of marriages are those where the fecundity of marriages is least ;" and also "that the countries where marriages are most numerous are those where the mortality is greatest."

Quetelet states that 100 marriages in Northern Europe produced 430 births ; in Southern Europe, 457. This he attributes to the late period of marriage in the north, and to the precocity of the inhabitants of the southern countries. There are more births in towns than in the country, due to the higher marriage rate, and women marry earlier in life.

The reports of births and deaths in Scotland make three divisions of the people :—

1. Those living on the islands.
2. Those living in the country of the mainland.
3. Those living in the great cities.

During the fourteen years reported, the proportions of deaths of children for every 100 births in each class were—

	UNDER ONE.	UNDER FIVE.
Islands, . . .	8·05	15·58
Mainland Country, .	9·80	18·56
Cities, . . .	14·91	30·90

The death-rate also varies in different countries : thus, in England, it is about 1 in 51·0 ; in France, 1 in 39·7 ; in Sweden and Belgium, 1 in 47·0 and 1 in 43·1 respectively. The number of deaths is greater in England

in towns than in the country—in the proportion of 144 to 100; and greater also where the sanitary arrangements are incomplete. The death-rate varies also in different parts of the same town, varying in proportion to the density of the population. The east end of London shows a marked increase of the death-rate as compared with the west end. Thus, the death-rate of London, as a whole, is no criterion of the healthiness of its individual portions. Dr Stokes says:—"Since the introduction of sanitary measures, the death-rate of the three great capitals, and of the gaols on the continent of India, is stated to be greatly lessened. Calcutta shows better than Liverpool or Manchester, and the death-rate of Bombay is less than that of London."

Hot and cold climates materially increase the death-rate; but this, as above shown, may be checked by the adoption of sanitary measures. The climate of the British Isles, with "a mean range of only 20° between summer and winter, cloudy skies, and frequent rains, with a high relative humidity, so far from acting injuriously on the health of the people, conduces to the greatest activity of mind and body, to a high standard of health, and to longevity." Elevation above the sea is also favourable to longevity—well seen in Norway, Scotland, and the mountainous parts of France and Switzerland.

But beyond the mere questions of birth and death-rate, locality has an intimate relation to the productions of the soil, the methods of cultivation, the manners of the people, the forms of government, the religion, and the diseases by which the inhabitants are attacked. Thus, certain geographical areas are marked by special diseases, which, as they are always more or less present among the inhabitants, are said to be *endemic* to those localities; thus, yellow fever is endemic in the West Indies, cholera in India, ague in Essex, goître in Derbyshire, etc. Some diseases may spread to other

countries, where they rage as *epidemics*, but do not become endemic—*i.e.*, cholera. Others do not appear to have any special local habitat, and are thus said to be pandemic—*i.e.*, small-pox, measles, etc.

Mere geological structure may have little to do with the causation of disease, although it is held by some that cholera is unknown on granitic soils; but the permeability or the impermeability of the soil probably has a great deal to do with the prevention or causation of certain diseases. Thus, damp, clay soils are attributed with rheumatism, catarrh, and neuralgia; alluvial, containing large quantities of organic matter, give out malaria, although not marshy; while the gravels, sandstones, chalk, etc., are considered, as a rule, healthy,

But the healthiness of these soils entirely depends on their being kept entirely free from sewage and decaying organic matter. A locality may be rendered unhealthy, especially in a tropical climate, by the incautious disturbance of the surface soil impregnated with decaying organic matter. The obvious precaution is not to build on such land till it has been freely opened and oxygenised. Dr Bowditch has shown that the frequency of phthisis in certain localities is notably diminished by proper drainage, which is only another proof that the public health can be improved by keeping the soil clean through good drainage. (See also Dr Buchanan's Report on the same subject in the Tenth Report of the Medical Officer of the Privy Council.) From the Fens, ague has been almost entirely banished, due to improved systems of drainage adopted in those districts. But a curious fact is recorded by Denton on the observations of Mr Marshall of Ely. Ague has in some places recurred, but not, as formerly, during *spring*, but during *autumn* — the explanation given by Mr Marshall being that "the drainage had been carried beyond the point of prudence, so that in the summer months, and especially towards harvest, the Fen ditches became *nearly dry;* and the consequenc

was that we once more got an exhaling surface, and a noxious effluvium arising from decaying vegetable matter." "This state of things," continues Mr Marshall, "is now quite altered and the ague has again vanished, owing to the farmers making it a rule to let water in from the rivers during the summer months, so as to 'keep a water' always in the fen ditches." It should always be borne in mind that a house having a higher temperature than the surrounding air acts as an exhauster of the soil beneath, and this is shown by the smell of gas present in a house not supplied with gas, the presence of the smell being the result of permeation through the soil of gas from a neighbouring broken gas-pipe. The effluvia from cesspools or drains may be thus drawn into a house, especially if the soil be loose or gravelly; and this may occur even in severe winters with the ground frozen solid for some feet below the surface. The presence and amount of water in the soil also demands attention, and necessitates a good system of subsoil drainage. The observations of Pettenkofer on the wells of Munich suggested to Buhl the probable relationship between the height of the ground water and epidemics of fatal typhoid fever, the outbreaks occurring when the ground water was lowest, but especially when it had reached an unusual height, and had then rapidly subsided. This view, although confirmed by subsequent observations in Germany, has not yet been accepted in England, where impurity in the drinking water is generally accredited with the causation of the outbreak.

Pettenkofer considers the following conditions to be necessary for the production of typhoid fever:—

1. Unusual height of ground water followed by a rapid sinking.
2. Impurity of the soil from animal impregnation.
3. Heat of the soil.
4. Presence of a specific germ.

It can easily be seen that when the ground water sinks, air is drawn into the soil; and that when the ground water rises, it is forced out more or less impregnated with foul gases.

On the subject of cholera, Pettenkofer holds like views; but these have not been accepted in Germany, and the weight of evidence appears to be against them.

The height of water in a well may be taken as a good guide as to the amount of the subsoil water.

Deep drainage, and opening the outflow, are the only means to get rid of the excess of the subsoil water. While advocating a perfect system of subsoil drainage, Mr Denton lays great stress on the necessity of keeping the drainage of the soil distinct fron the sewerage, "inasmuch as the same apertures which let the water from the subsoil into the sewer will let the sewage out of the sewer into the subsoil whenever the pressure from within is greater than that from without; and we must also remember that whenever sewage itself escapes sewer gas will escape too."

Air in the Soil.—The amount varies with the nature of the soil—probably from 40 to 50 per cent in loose sands or gravel, and is being constantly changed. The amount of CO_2 probably owes its origin to organic processes going on in the soil. To test the air in the soil of any given locality, a long iron tube with a pointed solid end, but with small holes near its extremity, is driven into the ground to the required depth, and an aspirator attached to the free end, when air can be drawn from the soil and examined. Owing to bad drainage and the presence of decaying animal and vegetable matter in the soil, the contained air may become impregnated with sulphuretted hydrogen, ammonium sulphide, carburetted hydrogen, etc. "It appears manifest to me that the escape of these constituents into the ground surrounding dwellings must be injurious,

for the gases evolved in sewers are frequently fired by the candles of sewer men; and in a case in my own practice, where an examination was being made of the condition of a sewer running *under* a large establishment, in which there were at the time 250 inmates, the confined gas took fire from a workman's candle, and passed through the entire length of a long basement. Little attention is at present given to matters like this, though they cannot fail to show that sewers with air-tight joints are desirable near dwellings. If they are air-tight they are necessarily water-tight, and then the sewage itself, with its 72 parts of dissolved solids in 100,000 parts, will not escape into the soil surrounding the sewer, to render it 'excrement sodden,' and gravitate by soakage to the foundations and basements" (J. B. DENTON).

Air in Soil—How estimated?—In the case of rocks, first, after careful drying, determine specific gravity, and then weigh before and after submersion in water. Thus—

$$\frac{\text{Weight of water taken up} \times 100}{\text{Weight of dry rock} \div \text{specific gravity}} = \text{percentage of air.}$$

In the case of loose soil, dry soil at 100° C. (212° F.), reduce to coarse powder and place it in a burette, gently tapping it to expel as much air as possible. Take another burette, and connect by india-rubber tube the bottom of it to the first, taking care to have a stop-cock between them. Into No. 2 pour some water; then open the stop-cock, and allow some water to rise gradually through the soil in No. 1, so that the water stands just above the soil. Read off from No. 2 the quantity passed through to No 1, and calculate as follows:—

$$\frac{\text{Amount of water used} \times 100}{\text{Cubic centimetres of dry soil}} = \text{percentage of air.}$$

Ground Water.—Soil partly filled with air and water is said to be *damp;* but when all the air is expelled by the water, the degree of humidity thus reached is called *ground water.* It commences at the lowest limit of the air in the soil. The ground water is due partly to rain, and partly also to the rising by capillary attraction of the water flowing on the surface of the more impermeable rocks. Two gallons of water may be contained in a cubic foot of loose sand, and one in the same bulk of ordinary sandstone.

How Measured?—By taking the depth of the water in the wells in the neighbourhood. This may be done by attaching a series of cups at equal distances along a rope, and carefully letting the rope down; the last cup filled will nearly give the depth of the water. A wooden rod is better than a rope, as the latter has a tendency to stretch. The amount of moisture in the soil may be determined by drying a weighed quantity at a temperature of 220° F., and noting the loss of weight; or the soil may be dried, weighed, and then exposed to the air, the increase of weight will give the amount of moisture taken up.

It is one of the duties of a Medical Officer of Health to make himself aquainted with the geological and topographical characteristics of the district over which he presides. This he can readily do by a study of the ordnance maps published by the Surveyor-General.

4. Periods. — At different periods in the same country, we find a marked difference between the number of marriages, births, and deaths. Thus at certain periods, when corn is cheap, and the cost of living small, there are more marriages, followed by an increase of births, than at those periods when corn is dear, the result of either the effect of bad harvests or war. The number of the deaths varies also at different epochs. The mortality is not, as a

rule, increased during the period of famine, but during the years which follow, as a result of the diseases brought about by want of proper food.

Quetelet observes that "it is remarkable that epidemics, famines, and all great pestilences, exercise a marked influence not only on the mortality, but also on the number of marriages and of births."

1. *Periods of Scarcity.*—	1843	70·499	Before the famine.
	1844	75·055	
Irish Famine,	1845	86·900	During the famine.
	1846	122·889	
	1847	249·335	
	1848	208·252	After fluctuation and decrease.
	1849	240·797	
	1850	164·093	

2. *Periods of War.*—Two causes at work.
    1. Increased mortality of adult males.
    2. Decrease in marriage and birth-rate.

3. *Epidemics.*—Rapid increase of death-rate.

5. Seasons.—The number of births and deaths is more or less affected by the seasons of the year: thus, the maximum of deaths occurs about the month of January, that of births during February; the minimum of both being reached about July. The effects of winter having passed off, and the vital forces being most active, most conceptions take place in May, followed by an increase of births in the following February. The effect of the seasons is more marked in the country than in towns.

Certain diseases are more marked in their prevalence and intensity at one season of the year than at another, and this appears to have some indirect relationship to the varying stages of the organism at those seasons.

A rapid fall of the thermometer in winter is followed by a rapid rise in the death-rate, from chest affections in the young, the aged, and the weakly. It is a curious fact that after an intense and prolonged frost the

death-rate rapidly increases on a break-up of the frost, the sudden increase in temperature being more fatal than the cold. In other words, sudden change is more fatal than a continuance of cold.

In summer, excessive heat is also attended with an increased mortality from diarrhœa, especially among children.

TABLE SHOWING THE INFLUENCE OF THE SEASONS ON ZYMOTIC DISEASES.

WINTER.	SPRING.	SUMMER.	AUTUMN.
Cholera occasionally occurs as an epidemic during this season, especially if the weather be very mild.	Measles.	Measles.	Cholera. Chiefly at this season.
Cerebro - Spinal Meningitis.	Cerebro-Spinal Meningitis.	....	Cerebro-Spinal Meningitis.
Small-pox.	Small-pox.	....	Scarlet Fever.
Whooping-cough.	....	....	....
Typhus. Due probably to over - crowding in the cold seasons of the year, from want of proper fuel for heating the dwellings.	....	....	....

The state of civilisation to which the inhabitants of a country attain is in a great measure due to the seasons.

Agriculture flourishes in countries where the seasons are favourable ; and in no country was this more noticeable than in Egypt. The regular overflow of the Nile at a certain time of the year made Egypt the granary of the ancient world. As a nation becomes more agricultural, it becomes more civilised.

TABLE SHOWING THE EFFECT OF THE SEASONS IN MODIFYING THE TYPE OF DISEASE.

	WINTER.	SPRING.	SUMMER.	AUTUMN.
Vital Activity—	Stationary maximum.	Maximum and decline.	Decline and minimum.	Minimum and increase.
Type of Disease—	Dynamic.	Change — Dynamic to Adynamic.	Adynamic.	Change—Adynamic to Dynamic.
Diseases of Respiratory Organs—	Inflammations, bronchitis, pneumonia, phthisis, brain diseases, apoplexy, typhus.	Inflammations, bronchitis, pneumonia, rheumatism, apoplexy, eruptive fevers.	......	......
Diseases of Digestive Organs, etc.—	......	......	Diarrhœa, cholera, plague.	Diarrhœa, eruptive fevers, inflammations.

The preceding Table is somewhat complicated, and is scarcely so explicit as might be wished; but the subject discussed is one of no ordinary difficulty, for we are dealing with two most unstable and complex phenomena—the human organism on the one hand, and the varying seasons on the other.

The data deduced from the death-rate—and at present we have no other source of information—can give or leave no correct idea of the prevalence of an epidemic, only of its *fatality*.

Besides, the type of the disease is modified by the condition of the system previously existing, and also by the power of the individual to resist the debilitating effect of heat, or respond to the invigorating power of a moderate degree of cold. This may help to explain the reason that only certain persons are attacked in winter or in summer by an epidemic, when the morbific element must be present to all.

The type of disease, also, is modified by the state of the system preceding the attack: thus, an individual bearing heat well does not suffer from debility to a like extent with one who is at his best in cold weather; and hence, in the former case, an attack of disease in summer is not so likely to prove fatal as in the latter.

In the case of children, Dr Edward Smith has arrived at the conclusion that a child born in the cold season has a higher probability of life than one born in the hot season.

6. Hours of the Day.—There can be no doubt that man is more liable to be attacked by disease during certain hours of the day than at others. More deaths occur during the early hours of the morning than at any other time. On this subject Dr Finlayson remarks:—"Hence we may either say that the period of minimum vital energy, which exists during the first few hours after

midnight, being deepened and perhaps prolonged, coincides with the summit of the death curve, or, phrasing it otherwise, that the time having arrived for a fresh rallying of the vital energies for a new day, the dying are found to be unable to respond to the call, and so they perish in greatest numbers at the very hours in which the living are manifesting, in every way, a renewed vigour." There is also greater liability to attacks of epidemic diseases during the night. On referring to the experience of cholera in this country, it appears that the great majority of seizures were between twelve at midnight and six in the morning. In Hamburg, the attacks were so generally in the night that, when the epidemic was at its height, many persons were afraid to go to bed at all; and it is remarkable that the same observation has been made with respect to plague, when it prevails as an epidemic." Dr Laidlaw says:—"I do not recollect to have been called to a fresh case of plague till between five and six in the morning." This liability to disease during the night is probably due to the diminished activity of the function of respiration and to the lowered tone of the system. The number of births is greater during the night than during the day, the ratio being as 5 to 4.

II.—MORAL OR DISTURBING.

Professions and Trades; State of Morality; Marriage and Prostitution; Institutions, Civil and Religious—all affect the number of Births and Deaths.

1. Professions and Trades.—The influence of professions and trades on the birth-rate of a country is in general masked by other forces, the exact influence of which is not easily determined; but their effect on the number of deaths is more easily appreciated.

The clergy are proverbial for large families.

A state of slavery appears to diminish the fecundity of marriages.

With regard to the effect of professions and trades on the morality of a country, more definite data have been obtained.

The state most favourable to man is that in which he leads a regular life, with sufficient for his wants, without having his passions excited by the profligacy of the towns.

Certain professions and trades are more obnoxious to long life than others.

Thus, the researches of the late Professor Casper, contrary to the generally received opinion, show that the medical profession is perhaps more liable to early death than any other, and that the clergy, in the list of mortality, occupy the opposite extreme.

Idleness and affluence are fruitful sources of disease.

All those professions, which from their very nature enjoin a more or less sedentary life, are injurious to health, and therefore to longevity.

Lawyers confined to the desk, schoolmasters, clerks, literary men, and others, precluded from taking exercise in the open air or doomed to work to late hours of the night, are, as a class, short-lived.

Literary men, unfortunately, lead most irregular lives, which may, more than their occupation, tend to shorten life.

Merchants are generally considered long-lived; but it is not improbable that the formation of railways, with the rapidity of transit, and the uses of the electric telegraph, which diminishes the dimensions of the earth, will have at no far distant date most injurious effects on the mercantile population. The rapidity with which the news of the fall in prices of the markets is now transmitted, and the anxiety to sell at once to save loss, or to buy in the hope of future profit, is gradually leading to a train of evils from which the future must suffer.

Shopmen, confined all day to close ill-ventilated shops, going to bed late and rising early, with little out-door exercise except on Sunday, when they are glad to rest after the labours of the week, frequently fall victims to phthisis, and die early.

Stone-masons, lapidaries, knife-grinders, quarrymen, coal miners, coal heavers, pin pointers, button makers, pottery workers, flax hacklers, etc., are subject to diseases of the air-passages and lungs, phthisis, etc., due to the inhalation of solid particles of matter. *Grinder's rot* is a form of consumption more properly chronic bronchitis, well known among knife and needle grinders. In mines and other places where blasting operations

are conducted the nature of the blasting material affects the character of the contained atmosphere, thus gunpowder adds carbonic acid, carbonic oxide, hydrogen sulphide, hydrogen and suspended particles of potassium sulphate ; potassium sulphide, sulphur, carbon, ammonium carbonate. Dynamite and gun-cotton add nitrous fumes, but no carbonic oxide or hydrogen sulphide. Roburite-chloro-dinitro benzol and ammonium nitrate—produces but a small quantity of carbonic acid and no smoke. In all trades in which dust is the existing cause of disease free ventilation and the use of respirators have to a great extent lessened the mortality. Wet grinding, where possible, and the use of ventilating boxes to carry off the dust as formed, has done much to prolong life among those engaged in these dangerous trades.

White-lead manufacturers, plumbers, and painters are liable to paralysis and to lead poisoning, known as "painters' colic." *Prevention*—Grinding the lead in oil, cleanliness and the use of lemonade mixed with dilute sulphuric acid.

Workers in mercury and gilders often suffer from a form of paralysis and salivation, called mercurialismus. *Prevention*—Free ventilation.

Chimney-sweeps are subject to cancer of the scrotum.

Phosphorus workers, to necrosis of the jaws. *Prevention*—The use of amorphous phosphorus in match making, and free ventilation.

Arsenical workers and artificial flower makers, to slow forms of arsenical poisoning. *Prevention.* — Personal cleanliness, free ventilation.

Bakers, to skin eruptions, lichen, etc. *Prevention*—Cleanliness, free ventilation, and shorter hours of work.

Brassfounders, tin-plate workers, and coppersmiths, to a peculiar form of ague and colic. The urine of copper workers is said to be green from absorption of the metal, but their health does not appear to be much injured.

Paraffin Workers.—Dr J. Bell has described a form of cancer, which he designates paraffin-epithelioma, among the workmen.

Quinine Manufactories.—The workers are often attacked by eczema of a very severe type, extending over the body.

Soda Factories.—The workers are attacked with erythematous eruptions. Their teeth become soft and translucent, and break off close to the gums (Layet).

Bichromate of Potash Manufactories.—The workmen suffer from troublesome sores, especially in the nose. *Prevention.*—The use of snuff is said to prevent the injurious effects of this substance.

The Caisson Disease.—Men working in the large wooden or iron cases used in laying the foundations of bridges under water are subjected to extreme atmospheric pressure. When the men return to the surface, the diminished pressure produces severe pains in the joints and other troubles. In building the Forth Bridge, Belgian workmen accustomed to work in caissons had to be employed. The British workmen were unequal to the work.

Bleachers suffer from the effects of chlorine.

Straw-hat makers suffer from the sulphurous acid fumes used in bleaching the straw.

Shoemakers, from their sedentary habits, suffer in most cases from piles, and from the pressure of the last on the breast-bone.

> The prevention or at least the lessening of the injurious effects of any of the above trades may be thus summed up :—Personal cleanliness, free ventilation, short working hours, and healthy recreation in the open air.

Soldiers and sailors, if the former are not selected at too early an age, and the latter, when they escape the perils of their calling, are generally healthy and long-lived. The effect of recruiting the French army, in the time of Napoleon, with very young men was, that "they encumbered the road-sides and the hospitals." The late Anglo-Egyptian war has also shown the inefficiency of young soldiers. The earliest age at which the recruit should be admitted into the army is twenty ; and, if admitted, should not be sent on active service till he attains twenty-three or twenty-five years of age.

On the whole, then, those professions and trades which admit of a due exercise of the healthy functions of the mind and body, together with a due amount of out-door exercise, are conducive to long life ; and the contrary, to early death.

2. Morality.—Marriage and Prostitution.

(1) *Marriage.*—Marriage in young nations becomes a necessity. In many ancient nations marriage was strictly enjoined, and in some enforced by penal statutes. In more modern times much is left to individual pleasure ; but it may be fairly questioned whether this liberty is always beneficial, or for the best interests of the State. It leads too often to injudicious unions, with their train of evils, especially when two

unhealthy individuals unite to produce a progeny more unhealthy than the parent stock. A large percentage of the pauperism in England is the result of unthrifty marriages, and the system of out-door parish relief is to a large extent a premium on them, for the more in family the more relief. Promiscuous intercourse of the sexes has a tendency to diminish the number of births, and to lessen the natural expectation of life. There are more still-births among illegitimate than legitimate children, and the mortality is also greater during the early months of infantile life. "Le funeste héritage," says Quetelet, "du vice n'atteint pas seulement l'enfant avant sa naissance, il le poursuit longtemps aprés qu'il a échappé à ce premier danger; et la misère bien souvent aggrave encore le mal." Married men live longer than the unmarried. Herbert Spencer questions the truth of the last statement by pointing out that the increased longevity of married men is not due so much to the married state, as to the fact that the men who marry are those whose surroundings in life are most conducive to the prolongation of life; such, for instance, as easy circumstances, a more vigorous constitution, etc.—in short, everything which renders marriage desirable and practicable. There is a larger number of widows than widowers in Great Britain, and the proportion of the one to the other is greatest in our seaport towns.

Mr Milne gives the following reasons for the larger proportion of widows to widowers:—

1. Men are in general more *intemperate* than women.
2. They are exposed to greater hardships and dangers.
3. Widowers, perhaps, in general, have greater opportunities of getting wives than widows have of getting husbands.

The cost of living appears to affect the number of marriages, and on this subject Professor de Morgan remarks:—"When provisions are cheap, or wages high, when, in fact, it is easy to maintain a family, marriages are more frequent, and are contracted at earlier ages."

In London, the average number of children to each marriage is less than in the country, but the average of the whole country is about four for each marriage; and is is stated that when the relationship between the parents is very close, a large percentage of the children are more or less injuriously affected—insanity, blindness, dumbness, etc., being among the most frequent results.

(2) *Prostitution.*—This is one of the most difficult questions which may engage the attention of the State. That prostitution is a terrible evil no one will deny; but few are agreed as to the measures to be adopted for its suppression. Besides the terrible diseases which promiscuous intercourse of the sexes engenders, the effect on the morals of the community is not less disastrous. In foreign countries the State has interfered, and prostitution is to a great extent regulated by State enactments. In 1845, a law was passed in Prussia to suppress all the brothels in Berlin and other large cities. Severe penalties were also imposed on those engaged in public prostitution. The result was that illegal prostitution rapidly spread, and public morals became so bad that, after a trial of six years, prostitution was again legalised.

In the years 1864, 1866, 1869, certain Acts were passed, known as the "Contagious Diseases Acts;" but these, unfortunately, only applied to certain towns used as naval and military stations. Much opposition has arisen with regard to these Acts among a small number of well-meaning but misguided philanthropists, among whom may be noticed a few married and unmarried women. This misdirected opposition has resulted in a virtual repeal of the Acts in question.

In no other country but England is prostitution so open and so undisguised. The late Dr Parkes writes: "The effect of this upon the virtuous female population is very serious. Every servant in London sees the

fine clothes and hears of the idle and luxurious lives of the women of the town, and knows that occasionally respectable marriage ends a life of vice. What a temptation to abandon the hard work and the drudgery of service for such a career, of which she sees only the bright side! It is a temptation from which the State should save her. She should see prostitution as a degraded calling only, with its restrictions and its inconveniences."

If a means of gratifying the sexual instincts is imperative, and marriage is not possible in all cases, the unfortunate women, who may, as a rule, be regarded as the victims of male licentiousness, should be properly registered, domiciled, and placed under organised medical inspection. They should not be allowed to patrol the streets of our towns decked out in the most captious apparel, and enticing by their meretricious actions the young and the unwary.

Referring to the opinion of the late Dr Parkes on the Contagious Diseases Acts, the "Edinburgh Medical Journal" remarks:—"We are tempted to quote, in conclusion, the last dying testimony, so to speak, of this thoroughly informed witness in regard to the *questio vexata* which at present excites so many ignorant non-professional but well-meaning people—'The prevention of syphilis and gonorrhœa by periodical inspection of prostitutes, and removal of them to lock hospitals when diseased, is only carried out in this country in certain military and naval stations, where the effect has been to lessen primary syphilis by *nearly* one half, and to abate its virulence. The effect of the Contagious Diseases Acts upon the women, in respect not only of curing them, *but of influencing them for good, and for reclaiming them*, has been very remarkable. In Germany, France, and Belgium, precautions against venereal diseases have been carried out among the entire population for many years, with the effect of greatly lessening the amount and virulence of syphilis. As

primary syphilis has a most pernicious effect upon the health of a large number of persons, it is most urgently to be hoped that the Legislature may before long deal thoroughly with this matter, and attempt to lessen syphilis, not merely in the army and navy, but among the population at large.'"

3. Civilisation.—No one can doubt the beneficial influences of civilisation on the well-being of a country; and this influence is most marked in the diminished mortality among children, and the greater prolongation of human life. "I do not fear contradiction," says the late Professor Graves, "when I assert that the prolongation of human life is a decided advantage; because, in proportion as the judgment of the old is brought to act on the passions of the young, will the wisdom of nations accumulate, and the solidity of individual character be increased." But civilisation, though good in itself, unfortunately brings with it in most cases the means of over-indulgence, with its train of evils.

All religious excitement is injurious to the well-being of society, and the only effect of the wave of religious excitement which passed over us some years ago, known as "Revivalism," has been to increase the number of inmates of our lunatic asylums, and to leave the ignorant dupes of the movement in a deeper depth of licentiousness and hypocrisy than ever. Halloram reports that in the asylum in Cork the proportion of insane Catholics to Protestants is one to ten. Suicide is also more common among Protestants than Catholics. It is said that Protestants and Catholics differ in the form of madness to which each is liable. In the former, mysticism and a presumption to comprehend and explain the symbolic portion of Scripture, in the latter, apprehension of heavenly punishments, fear and despair; the first are mad because they believe that they are prophets sent from heaven; the second because they believe themselves damned (Marc).

Liberal institutions are most favourable to fecundity; and during periods of peace and plenty the number of marriages increases, with a consequent increase in the number of births. It is stated that in Catholic countries, where Lent is rigidly observed, the number of births is materially diminished. It appears also as well established, that civilisation has great power in diminishing the mortality, in diffusing prosperity and the most active means of preservation.

The following Table gives some important results, and is taken from the Geneva Records:—

THE DEATHS IN 10,000 BORN WERE—

PERIOD.	UNDER ONE.	UNDER THREE.
Sixteenth Century, . . .	2,592	4,435
Seventeenth Century, . .	2,372	4,100
Eighteenth Century, . .	2,012	3,316
1814 to 1833, ...	1,385	3,440

In the first period one half died before they completed their ninth year; in the last, one half survived their forty-fifth year.

The injurious effects of overcrowding are well known. Dr Farr remarks, in the Fifth Annual Report of the Registrar-General, page 419, that the mortality is not only greater in town than in country districts, "but that the mortality of town districts has a certain relation to their density."

The following Table will show the result of overcrowding on the Annual Mortality per 1000 in the Metropolis:—

SPACE FOR EACH PERSON.	MORTALITY.
32 Square yards, . . .	27·7
102 " . . .	24·4
202 " . . .	20·0

Emigration.—This subject has become a matter of great importance, as the necessity of getting rid of our surplus population becomes more imperative. "From the beginning," remarks Herbert Spencer, "pressure of population has been the proximate cause of progress."

Some have suggested the creation of small landed proprietors. This is admirably combated by a writer in the "Quarterly Review" for January 1872. He says:—"We feel the full beauty of the pictures they draw of the smock-frocked labourer sitting at his own door, under his own fig-tree, looking out on his own acres, and with his ten children—which he is sure to have—lying on the the sward around him. But when we think of the next step, and picture each of these ten children needing these ten acres also, the economic imagination breaks down before the unrealisable ideal. These peasants are *too thick upon the ground already*—that is the fundamental cause of their wretchedness; unless they emigrate, they will become thicker still, and rapidly so—and what then!"

But may we not, in reducing our population by emigration, be parting with the better portion, leaving only the infirm and debilitated behind to still further deteriorate the race?

Dr Acland remarks:—"The reality of our difficulty about population is told in a few words. England and and Wales are increasing by about 200,000 annually. This number will, of course, increase by a small increment. Since A.D. 1810, the population, which was 10,000,000, has become 22,000,000; and at the same rate, will, A.D. 1920, be over 45,000,000. The acres in England and Wales are about 37,325,000, including waste ground. There are now, therefore, nearly two acres per man; in fifty years there will not be one. In Glasgow, there are already 94 inhabitants to an acre, and in Liverpool 103."

Since Dr Acland wrote, the population has increased to 25,968,286 in 1881, and is now over 30,000,000. Certain writers of late have recommended the limitation of families by the use of certain "checks." These opinions have not generally been accepted, but there is much to be said on both sides of the question.

4. Intemperance—On this subject I shall quote somewhat largely from some valuable papers in the Annual Report of the State Board of Health of Massachusetts, kindly sent me by Dr H. I. Bowditch :—

First.—Stimulants are used everywhere, and at times abused, both by savage and by civilised man. Consequently intoxication occurs all over the globe.

Second.—This love of stimulants is one of the strongest of human instincts.

Third.—Climate law governs it.

Fourth.—Owing to this cosmic law, intemperance is rare near the equator.

Fifth.—Intemperance causes little or no crime towards the equator. It is the almost constant cause of crime, either directly or indirectly, at the north, above 50°.

Sixth.—Intoxication is modified by race, as shown in the different tendencies to intoxication of different peoples.

Seventh.—Races are modified physically and morally by the kind of liquor they use, as proved by examination of the returns from Austria and Switzerland.

Eighth.—Beer, native light wines, and ardent spirits, should not be classed together, for they produce very different effects on the individual and upon the race.

Ninth.—Light German beer and ale can be used even freely, without any apparent injury to the individual, or without causing intoxication. So also may light grape wines, unfortified by an extra amount of alcohol.

Tenth.—Races may be educated to evil by bad laws, or by the introduction of bad habits.

Eleventh.—A race, when it emigrates, carries its habits with it, and for a time at least those habits may override all climate law.

Twelfth.—England has thus overshadowed our *whole* country with its love of strong drinks, and with its habits of intoxication, as it has more recently covered Ceylon, parts of the east, and Australia. (In this Dr Bowditch is somewhat hard upon England.)

[The other divisions, nineteen in number, relate chiefly to suggestions for suppressing drunkenness in America.

"The present intemperate condition of the English is due to several causes, among which may be noticed—bad legislation, and war. The prohibitive duties on light French wines forced the English to seek in Portugal the strongly fortified port. This has been unfavourable to the moral status of England."

The writer of the paper also says :—

"As a warning to our people, by our present unwise and high tariff on the mild wines of Europe, the people of this country are led to use the only drinks provided for them—viz., the coarser liquors. Are we not, in so doing, following exactly in the absurd way, I do not say wicked example, set by England two centuries ago? The civilisation of Monarchial Britain of the seventeenth century governs, in fact, Republican America of the nineteenth."

Macaulay states that wine was given up in 1648, and that punch took its place; and worse than the change of brandy and lemonade for claret, was the increase of crime in 1692.

Total Abstinence.—On this subject opinions differ, and will continue to do so. The evidence of army surgeons, travellers, and insurance officers certainly go far to show that lessened rates of sickness and mortality follow the practice of total abstinence from intoxicants. It seems, however, impossible for any man to decide for another what he shall eat or drink. Legislative inactments have been, and will ever be futile to prevent the undue use of alcohol in any of its forms. Society must be raised to a higher level than it is at present before intoxication will be stamped out.

THE INDIVIDUAL MAN.

Man, whether considered as an individual or as a species, is affected by the same influences. "Man," says Draper, "is the archetype of society; individual development, the model of social progress."

In the following pages, man will be briefly considered as an individual, under four heads :—

1. Height. 2. Weight. 3. Strength. 4. Vital Capacity.

1. HEIGHT.—The length of the new-born infant varies from 16 to 24 inches, the males being, as a rule somewhat longer than the females. Towards the age of 16 to 17, the increase in the height of girls is relatively less than of boys between 18 and 19. In England, it has been shown that girls of 13 are, as a rule, taller than boys of the same age. This may be due to the earlier accession of puberty in the female than in the male. It appears also that the average height up to the age of 19 of those living in the country is greater than those who live in the towns; but that the average height of those who have reached the age of maturity is greater in the towns than in the country.

Much will, of course, depend upon the ease with which the necessaries of life are procured, and also on freedom from those influences which in early childhood have a tendency to dwarf the stature. It is also found that up to the age of puberty the height does not materially differ among the children of the lower classes, whether engaged in factories or not; but that it is after that period that the difference in favour of those who are not employed in factories is most marked.

The following are the conclusions arrived at by M. Quetelet, from an extensive examination of this subject :—

1. That the most rapid growth takes place immediately after birth, the infant growing, in the course of one year, about six inches.

2. That the growth of the infant diminishes in proportion to the increase in age, up to the fourth or fifth year, the period at which the maximum probability of life is reached. During the second year after birth, the increase of growth is about half what it was during the first; and a third, during the third year.

3. Reckoning from the fourth to the fifth year, the increase of growth becomes nearly regular as far as the sixteenth year, that is to say, just after the age of puberty; and this annual increase is about two inches.

3. After the age of puberty, the height continues to increase, but slowly. From the sixteenth to the seventeenth year, the increase is about one inch; in the two following years, about three-quarters of an inch.

> *N.B.*—In England, Mr Street found that from thirteen to fourteen, the increase in height in boys was one inch; fifteen to sixteen, three inches; sixteen to seventeen, four inches. Mr Roberts agrees with these statements, but shows that the increase between thirteen and fourteen is not so small, nor the increase from fifteen to sixteen so great as stated above.

5. The growth of man does not appear to entirely terminate at twenty-five years of age.

The following results are also taken from M. Quetelet:—

1. The limit of growth of the two sexes is unequal—
   (*a*) Because the female at birth is smaller than the male.
   (*b*) Because she arrives earlier at her full development.
   (*c*) Because her annual increase is somewhat less than the male.

2. The height of the inhabitants of towns at the age of nineteen is greater by half an inch to three-quarters than that of those who live in the country.

3. It does not appear that the growth of man is arrested at twenty-five.

4. Those individuals who live in ease and comfort generally exceed the average height; want and misery have a contrary effect, as obstacles to development.

5. The increase in the growth of the infant for many months before birth, until development is complete, follows a law of continuity, viz., that the rate of increase diminishes with the age.

6. Between the ages of five and sixteen, or thereabouts, the annual increase is pretty regular, and is a twelfth of the increase of the fœtus during the month which precedes birth.

7. In short, reckoning from the age of fifty, the man and the woman undergo a diminution in height which is more and more marked, and which may be estimated at from two to two and a half inches, till eighty years of age.

Certain external forces more or less affect the full development of man. The occupation of the parents is said to have a very decided effect on the size of growing children. Boudin, from his researches in France, concludes that stature is, to a great extent, "independent of comfort and misery, and is, on the contrary, closely connected with race." Thus, the average height is also less in very cold or very hot climates than it is in those countries where the climate is more temperate. Men are taller in the plains than in mountainous districts. The variety and ease with which food is obtained have a modifying effect. Some diseases, particularly fevers, have a marked effect in causing a rapid increase of growth. Lying in bed is also favourable to growth. A man is found to be taller in the morning than at night. Dr Aitken maintains that, in selecting recruits for the army, age, height, and weight should all be considered.

The late Dr Parkes held that "probably 62 inches at eighteen years of age, and 112 ℔s. to 116 ℔s. weight, should be a minimum when in times of greatest pressure. So also a very great height at eighteen years of age is objectionable, and anything over 67 inches at that age should be looked on with great suspicion. As a rule, also, adult men of middle size (67 to 69 inches) appear to bear hard work better than taller men."

2. Weight.—At birth the weight of the infant varies from 6 to 9 ℔s ; sometimes the latter is exceeded by a few pounds. Male children are also slightly heavier at birth than female. M. Chaussier—quoted and corroborated by Quetelet—states that the infant decreases in weight immediately after birth to the third day, and that it is not till after the first week of extra-uterine life that any increase in weight becomes appreciable. Weight up to a certain age increases with the height. After fifty years of age the height and weight gradually decrease. From birth to puberty the male

is slightly heavier than the female, but at that period they are about equal, or the female is slightly heavier than the male (Bowditch), the male again having the advantage with increase of age. At the age of forty man reaches the maximum of his weight, and at eighty he has lost more than 12lbs of his weight. The woman attains her maximum of weight at fifty. Reckoning from about the age of nineteen, her weight does not vary much till after the catamenia have ceased.

When fully developed the male and the female weigh about twenty times what they did at birth, and are about three and a quarter times the height they were at the same period. Infants a year old are three times the weight they were at birth; at six they are twice as heavy, and at thirteen four times as heavy as they were at one year. Immediately before puberty both sexes weigh about half of their ultimate weight.

From birth, and during the first year, the weight of the child is the cube of the height, but after this period to puberty the growth is less rapid; the weight is then the square of the height.

As the relative weight and height of individuals given by Quetelet apply more particularly to Belgium, I have not inserted them here; but the following Table of Dr Hutchinson, based upon 2650 observations, may be taken as a standard:—

Height.	Weight.	Medium Chest Measurement.
5 feet 1 inch.	8 stone 8 lbs.	34·06 inches.
5 " 2 inches.	9 " 0 "	35·13 "
5 " 3 "	9 " 7 "	35·70 "
5 " 4 "	9 " 13 "	36·26 "
5 " 5 "	10 " 2 "	36·83 "
5 " 6 "	10 " 5 "	37·50 "
5 " 7 "	10 " 8 "	38·16 "
5 " 8 "	11 " 1 "	38·53 "
5 " 9 "	11 " 8 "	39·10 "
5 " 10 "	12 " 1 "	39·66 "
5 " 11 "	12 " 6 "	40·23 "
6 " 0 "	12 " 10 "	40·80 "

In all weighings the weight of the clothes must be considered, and, as a rule, the average weight of the clothes, for all ages, may be taken at 8 per cent. for boys and 6·8 per cent. for girls, of the gross weight.

3. Strength.—The strength of man is measured by an instrument contrived by M. Regnier, and called by him a "dynamometer," from δύναμις, *force, vital power*, and μέτρον, *measure.* This instrument is by no means as perfect as could be wished.

The *lumbar power* of a man is the weight he can carry on his back. According to Regnier, a man from twenty-five to thirty years is in the zenith of his strength, and ought to press with both hands with a force equal to about 100 lbs.; and, on the other hand, he should be able to lift a weight of about 286 lbs. The strength of a woman is considered as about equal to that of a boy from fifteen to sixteen years of age.

We have now to consider the work done by a man in his various daily occupations. Work is said to be done by a *force*, which produces acceleration or when it maintains motion unchanged in opposition to resistance. *Work* is also directly proportionate to the weight raised, and also to the height through which it is raised. For all practical purposes the unit of work is taken as one pound lifted one foot high per minute. The foot pound is not an invariable quantity, as it differs at different places, being somewhat greater at the poles than at the equator. The external daily work of a man has been estimated at $\frac{1}{6}$th of the work of a horse, or 1263 tons raised one foot high in a day's work of 10 hours. This is probably too high.

To calculate the work done by men :—

$$\frac{(W + W^1) \times D}{20 \times 2240} = \text{number of tons raised one foot.}$$

W = weight of the man. W^1 = weight carried. D = distance walked in feet. 20 = co-efficient of traction; 2240 = pounds in a ton. To get the distance in feet multiply 5280 by the number of miles walked.

Walking on a level surface at the rate of three miles an hour, is equivalent to raising a twentieth part of the weight of the body through the distance walked, and this appears to be the rate at which the greatest amount of work can be done at the least expenditure of energy.

As an example it may be asked—How much work is done by a man walking at ordinary velocity a distance of 15 miles on an ascent of 1 in 200, the weight of the man and what he carried being 176 pounds? State the answer in foot tons.

$$\frac{176 \times 15 \times 5280}{20 \times 2240} = x \text{ foot tons.}$$

But the man also walked up 396 in the 15 miles.

$$\frac{176 \times 396}{20 \times 2240} = x \text{ foot tons.}$$

The total amount of work done will be the values of x added together.

4. Vital Capacity.—The "vital capacity" of man, or better, the "extreme differential capacity," is a term used to express the total amount of air that can be given out by the most forcible expiration, following on a forcible inspiration. Vital capacity appears to be dependent on stature, the average being about 230 cubic inches at 5 feet 8 inches, increasing or diminishing 8 cubic inches for every inch above or below that height. At thirty-five years of age the vital capacity of an individual is at its maximum; it then declines to sixty-five years. The "vital capacity" may be measured by a *spirometer*, a modification of a gas-meter.

Table giving the Rate of the Pulse and Number of Inspirations at Different Ages.

Ages.	Pulsations.			Inspirations.		
	Average.	Max'm.	Min'm.	Average	Max'm.	Min'm.
0 to 1 year,	136	165	104	44	70	23
1 " 5 years,	88	100	73	26	32	23
10 " 15 "	78	98	60	26	32	23
15 " 20 "	69·5	90	57	20	24	16
20 " 25 "	69·7	98	61	18	24	14
25 " 30 "	71·0	90	59	16·0	21	15
30 " 50 "	70·0	112	56	18·1	33	11

The pulse rate is increased when the individual is standing by two or three beats above that when sitting down. The rate also varies during the day, and is increased by muscular activity, food, increased temperature during disease—10 beats for every degree above 98° F., painful sensations and mental emotions, debility, etc.

The respirations vary per minute in the following positions—horizontal, 13; sitting, 19; standing, 22.

TABLE OF VITAL CAPACITY OR RESPIRATORY POWER.

	INSPIRATION.	EXPIRATION.
Weak	1½ inches	2 inches Mercurial Manometer.
Ordinary	2 "	2½ " "
Strong.............	2½ "	3½ " "
Very strong	3¼ "	4½ " "
Remarkable......	4½ "	5⅘ " "
Very remarkable	5½ "	7·0 " "

VITAL STATISTICS.

The study of the laws which govern the physical condition of mankind forms that branch of general statistical science to which the term Vital Statistics has been applied. The births, deaths, and marriages, together with the results of diseases of age and sex, and of those diseases incident on the occupation of individuals, all comes under the investigation of the vital statistician, and for the sources of his information on these subjects he has recourse to the census returns, and to the published registered returns of births, deaths, and marriages.

The *data* on which this branch of the science is based are individual facts, or so-called "numerical units," all of the same nature, and which admit of their being compared with one another, added together, and classified. Each unit must have

precise, definite, and constant characters, or else all classification is useless.

Dr Parkes remarked :—" In other words an accurate diagnosis of the disease is essential, or statistical analysis can only produce error. If the numerical units are not precisely comparable, it is better not to use them. A great responsibility rests on those who send in inaccurate statistical tables of diseases; for it must be remembered that the statist does not attempt to determine if his units are correct—he simply accepts them; and it is only if the results he brings out are different from prior results that he begins to suspect inaccuracy."

The uses of Vital Statistics—

1. Information as to the health of the people.
2. Information as to the good or evil conditions affecting the people, and which enables us to take precautions against the spread of disease, etc.
3. Their application to Life Assurance, by which individual members may relieve the State of the burden of keeping their offspring, etc.
4. The fatality of different diseases at varying ages, and the protection of individuals at these critical periods.
5. The influence of professions, trades, locality, age, on the well-being of the community.

The first step is to arrange, by taking some distinctive feature, the isolated facts that are represented to us into groups or divisions. Having arrived at some sort of classification, we next compare each group with the total number of units taken together, and also with each other. For the sake of convenience we take a 100, or some multiple of a 100, as our numerical *constant*. Thus, suppose the total number of deaths from all causes is 8212—of which 1378 are the result of zymotic disease, 3646 local, 224 violent, and so on, the percentage of deaths in each group will be found as follows :—

8212 : 100 : : 1378 :	16·8	percentage	of zymotic deaths.
8212 : 100 : : 3646 :	44·4	"	of local deaths.
8212 : 100 : : 224 :	2·7	"	of violent deaths.

But suppose we want to know the relative percentages between deaths and recoveries, we may proceed as follows. Take, for instance, 362 cases of pneumonia, divide into two groups, the deaths and the recoveries —19 of the former and 343 of the latter,—and then proceed thus—

362 : 100 : : 19 : 5·248 per cent. of deaths.
343 : 100 : : 19 : 5·54 per cent. of recoveries.

THE ARITHMETICAL MEAN OR AVERAGE.

This is obtained by dividing the sum of the units by the number of them. Thus, suppose the average of the deaths for any number of years is required; add all the death-rates together, and divide by the number of years. The arithmetical mean is, however, only reliable with regard to future results, when the units we use are very considerable. Thus, the average deduced from an examination of the death-rate for one hundred years would be more nearly correct than one deduced from ten years. In calculating averages, it is also advisable to take note of extreme values, that is, the highest and lowest units on each side of the mean ; for, as Dr Guy remarks, "averages are numerical expressions of probabilities—extreme values are expressions of possibilities." (See Professor Radicke on "Arithmetic Means," Syd. Soc., 1871.)

The Probable Error of The Arithmetical Mean.

The sum of departure from the average within which, on one side or the other, it is an even chance that the truth exists. This may be found by Poisson's rule, based on the "Theory of Probabilities," Dr Parkes stated this rule as follows :—

Let μ be the total number of cases recorded,
m be the number in one group,
n be the number in the other,
So that $m + n = \mu$

The proportion of each group to the whole will be respectively $\frac{m}{\mu}$ and $\frac{n}{\mu}$; but these proportions will vary within certain limits in succeeding instances.

The extent of variation will be within the proportions represented by

$$\frac{m}{\mu} + 2\sqrt{\frac{2.\ m.\ n.}{\mu^3}}$$

and

$$\frac{m}{\mu} - 2\sqrt{\frac{2.\ m.\ n.}{\mu^3}}$$

It will be obvious that the larger the value of μ, the less will be the value of $\sqrt{\frac{2.\ m.\ n.}{\mu^3}}$, and, consequently, the less will be the limits of error in the simple proportion $\frac{m}{\mu}$

An example will show how this rule is worked. The following is given by Gavarret ("*Statisque Medicale*," 1840, p. 284):—Louis, in his work on Typhoid Fever, endeavours to determine the effect of remedies, and gives 140 cases, with 52 deaths and 88 recoveries. What is the mortality per cent., and how near is it to the true proportion?

$$m = 52 = \text{number of deaths.}$$
$$n = 88 = \text{number of recoveries.}$$
$$\mu = 140 = \text{total number of cases.}$$

i.e., 37 deaths in 100 cases, or more precisely, 37,143 deaths in 100,000 cases. How near is this ratio to the truth? The possible error is as follows—the second half of the formula, viz.:—

$$2\sqrt{\frac{2.\ m.\ n.}{\mu^3}}$$

will be

$$2\sqrt{\frac{2 \times 52 \times 88}{(140)^3}} = 0{\cdot}11550 \text{ to unity.}$$

(Or 11,550 in 100,000.)

The mortality in these cases being 37·143 per cent., or 37,143 deaths in 100,000 cases, it may be in other 140 cases either

37,143 + 11,550 = 48·693 per cent.
or 37,143 − 11,550 = 25·593 "

In other words, in successive 140 cases the mortality will range from 49 per cent. (nearly) to 26 per cent. (nearly), so that Louis' numbers are far too few to give even an approximation to the true mean.

METHOD OF DETERMINING AGGREGATE POPULATION.

For the purposes of registration, the country is divided into registration and sub-registration districts, entirely supervised by three Registrars-General—one for each division of the kingdom. Under these authorities, weekly, quarterly, and yearly Reports are published. The first English Registration Act was passed in 1838, and amended in 1871. The Scotch Act was passed in 1855.

In the registration returns, in spite of every precaution to ensure correctness, certain fallacies may result thus :—

1. Births.—Not registered, due to ignorance of the law, or stupidity. Illegitimate births to avoid shame. To escape vaccination.

2. Deaths.—Errors of diagnosis, and, therefore, useless medical certificates. Cause stated merely by friends or relations in country districts.

3. Errors with regard to exact age of children or adults.

The Census.—This is the actual enumeration of the people effected every ten years, and was first commenced in 1801. For this purpose, schedules are issued to every householder, who has to make a return of every one sleeping in his house on the date appointed for making the returns. The forms supplied contain blank spaces for—(*a*) name, (*b*) sex, (*c*) age, (*d*) rank, (*e*) profession or occupation, (*f*) condition, (*g*) birthplace, (*h*) relation to head of the house. The returns are collected the next morning, and forwarded to the office of the Registrar-General, where the necessary classifications are prepared.

HOW ARE ESTIMATES OF POPULATION CALCULATED?

"The rate of increase can most conveniently and most simply be calculated by the aid of logarithms. Instead of taking the difference between the population enumerated in 1861 and 1871, the difference between the logarithms of these two numbers affords the true method for ascertaining the *rate of increase.* The logarithm of the population of Sheffield in 1861 is 5·2675753, and that of the population in 1871 is 5·3801136; the difference between these logarithms is 0·1125383, which is the logarithm of the rate of increase of population in Sheffield during the ten years 1861-71. If this logarithm of the rate of increase be added to the logarithm of the population in 1871, the number corresponding to this new logarithm will be the estimate of the population at the next census in 1881, which will be found to be 310,992 (or 70,975 more than the enumerated population of 1871). Having obtained the logarithm of the ten years' increase (0·1125383), a tenth of this will give us the logarithm of the annual rate of increase; by inserting a cypher to the left of the logarithm we shall divide it by 10, and 0·0112538 will be the logarithm of the annual rate of increase. The Registrar-General usually estimates his populations, for calculation purposes, to the middle of the year, and as the census is taken at the end of March or beginning of April, a quarter of a logarithm of the annual rate has to be added to the logarithm of the enumerated population to obtain the logarithm of the estimate for the middle of the year 1871. The logarithm of the annual rate in Sheffield, divided by 4, gives 0·0028135, which, added to the logarithm of the enumerated population in 1871, gives the logarithm of the population in the middle of 1871, namely, 5·3829271. Having thus obtained the logarithm of the population in the middle of 1871, the successive addition thereto of the logarithm of the annual rate of increase (0·0112538) will give the logarithm of the population in the middle of 1872, 1873, and so on up to the middle of 1881, by which time a new census will give a new starting-point. The addition of eight and a quarter times the logarithm of the annual rate of increase to the logarithm of the enumerated population of Sheffield in 1871 gives the logarithm 5·4729575—the number to which is 297,138. This is the Registrar-General's estimate of the population of the borough of Sheffield in the middle of this year. . . . The reverse operation—that is, deducting the logarithm of the annual rate of increase from the logarithm of the estimated population in the middle of 1871,—will give the logarithm of the population in the middle of 1870; and by repeating this operation, the logarithm of the populations in the middle of each of the years back to 1861 may be obtained."—(*Sanitary Record*, 1879.)

In the above extract, the rate of increase in a town is taken, but it is obvious that the same method may be applied to the country at large.

METHOD OF ESTIMATING THE DEATH-RATE OF A DISTRICT.

For ordinary purposes, and when the district is not large, the annual death-rate may be found by multiplying the quarterly death-rate by 100, and then, by 4, and dividing by the estimated population.

The following is the method adopted by the Registrar-General :—

"In the first place, it is scarcely necessary to say that all the rates now published by the Registrar-General, whether they relate to a year, a month, or a week, are annual rates to 1000 persons living—that is, these published rates represent the number of persons who would die in a year in 1000 of each population, if the proportion of deaths to population recorded in the shorter periods of a week, or a month, or a quarter, were maintained throughout a whole year.

"Let us take a rate of mortality from the Registrar-General's weekly return, relating to the seven days ending 31st July, as an example. We find, in Tables 1 and 2 of that return, it is stated that the estimated population of the borough of Sheffield in the middle of 1875 is 267,881 persons; that 127 deaths were recorded within the borough during the week under notice; and, further, that these deaths were equal to an annual rate of 24·6 per 1000 of this estimated population. Now for the operation by which this result is arrived at. We have the deaths in a week, and the estimated population in which they occurred, it is desired to find the number of the deaths which would occur in each 1000 of this population, if the same number of deaths were recorded in each week throughout a year. If a week were the correct fifty-second part of a year, it is obvious that either the deaths must be multiplied by fifty-two, or the population be divided by fifty-two, in order to make the population and the deaths comparable. As, however, the correct number of days in a natural year is 365·24226, the number of weeks in a year is 52·17747. The Registrar-General, therefore, for the purpose of this weekly return, divides the estimated population of each of the towns dealt with by 52·17747, which gives what may be called the weekly population of each town. The population of Sheffield divided by 52·17747 gives a weekly population of 5134 persons; this number serves as a *constant*, throughout the year 1875, by which to divide the number of deaths. The 127 deaths in Sheffield during the week ending 31st July, divided by this so-called weekly population, gives an annual rate of 0·0247 to each

person of the population; and by removing the decimal point three places to the right, or, in other words, multiplying by 1000, we arrive at 24·7, which is the correct annual rate of mortality per 1000 of the estimated population of the borough of Sheffield during that week. It would undoubtedly be more logical to multiply the deaths by 52·17747, than to deal with the population; but this operation would have to be repeated each week, whereas there is a manifest convenience, and an arithmetical economy, in the reverse operation (the effect of which is, of course, identical), which supplies us with a *constant* that is applicable throughout the fifty-two weeks of 1875. For all practical purposes the multiplication of the deaths in a week by fifty-two, in order to divide them by the estimated population, will afford the means of arriving at an approximately correct annual rate of mortality; or the reverse operation, the division of the population by fifty-two, may be resorted to.

"For the calculation of annual rates of mortality in a month, or a quarter, the Registrar-General takes account of the number of days in each month or quarter, and it is found more convenient to deal with the population according to the method described in the calculation of the annual rate of mortality in a week. The populations to be dealt with are divided by 365·24226, and must then be multiplied by the number of days in a month, or a quarter, in order to arrive at the population which may be applied to the deaths in a month or a quarter; by this means, a scientifically correct annual death-rate in those respective periods will be obtained. Approximately correct annual rates of mortality in a month, or a quarter, may be calculated by using a twelfth or a quarter of the population respectively as the divisor of the number of deaths recorded in those periods; but inasmuch as the length of a month varies from twenty-eight to thirty-one days, and of a quarter from ninety to ninety-two days, it is evident that a correct annual rate of mortality can only be calculated by taking into account this variation in the number of days in those periods, and that rates calculated without correction for these inequalities will differ from the rates published by the Registrar-General.

"In conclusion, it may be noted that rates published in the quarterly returns of the Registrar-General for the eighteen largest English towns, relate to the period of thirteen weeks, most nearly corresponding with the natural quarter; and that the population employed in this calculation is thirteen times that used for the rates in each week, and differs slightly from the population that would be used if the period of observation were three entire calendar months instead of thirteen weeks. The facts published in the quarterly return for all other parts of the country, except the eighteen largest English towns, relate to the natural quarters of three calendar months, and the population used to produce the annual rates of mortality therein are manipulated in the manner before described." —(*Sanitary Record*, 1875.)

In comparing the mortality statistics of one period with that of another, the following points have to be considered :—

1. Fluctuations of population.
2. Prosperous or adverse times.
3. Peace and war.
4. Favourable or unfavourable weather.
5. Social conditions and occupations.
6. Improved sanitary arrangements, new water supply, improved drainage, etc.
7. Epidemics.

A knowledge of the vital statistics of his district is necessary for every Medical Officer of Health. He may obtain a general knowledge of this subject from the quarterly and annual Reports of the Registrar-General, and he may become specially informed as to his own district by referring, in addition to the above, to the books of the District Registrar, and also to those of the Board of Guardians. From the latter he will be enabled to extract the value of the sick-rate, and the amount of pauperism and parochial relief. A return of births and deaths is forwarded, by the instructions of the Registrar-General, to every Medical Officer of Health from the District Registrar.

The Registers of Births, Marriages, and Deaths contain the following facts :—

Births—(*a*) Date, (*b*) Sex, (*c*) Place of Birth, (*d*) Number (twins, etc.), (*e*) Legitimacy, (*f*) Residence of Parents.

Marriages—(*a*) Name, (*b*) Age, (*c*) Occupation, (*d*) Residence, (*e*) Condition of Husband and Wife.

Deaths—(*a*) Date, (*b*) Name, (*c*) Residence, (*d*) Age, (*e*) Sex, (*f*) Occupation, (*g*) Condition, (*h*) Cause of Death.

From these returns, the Health Officer is enabled to make the following important weekly returns as to the sanitary condition of his district :—

1. *Birth-rate*—(*a*) Live-born. (*b*) Still-born.
2. *Marriage-rate.*
3. *Total Death-rate*—That is, the proportion of births, marriages, and deaths to the total population of the country or district.
   - *A.* Death-rate at different ages.
     - (*a*) In Infancy—1. First week. 2. First year.
     - (*b*) In Adults.
   - *B.* Death-rate from zymotic diseases.
   - *C.* Classified death-rate from other causes, violence, etc.
4. Degree of healthiness or unhealthiness of his district.
   - *A.* Number of persons constantly sick, arranged according to age, sex, occupation, disease.
   - *B.* Average duration of illness.

In preparing these returns, certain precautions have to be taken. Thus, suppose a district divided into urban and rural for sanitary purposes—both districts, however, combined in one Union, with the workhouse situated in the urban district; the death-rate and sick-rate will be increased in the urban and lessened in the rural; and unless allowance is made, a false return will be the result. A correction must, therefore, in all cases be made. Many of the deaths at sea-side places of resort are imported deaths, and should, if possible, be eliminated.

The "Rate of Mortality" and "Expectation of Life."

1. The number of deaths, say per thousand, within any given area, is known as the *rate of mortality*.

2. By the term "expectation of life," or rather "after life-time," is meant the probability of the age any one person of a given population may attain according to the rate of mortality found to prevail within that area, regard being had to the age of the party at the time of fixing the expectation. At birth the *after life-time* and the *life-time* are the same.

The following is Willich's formula for calculating the expectancy of any age x:—

Expectancy of life $= \frac{2}{3}(80 - x)$.
Expectancy, 6 years of age $= \frac{2}{3}(80 - 6) = \frac{2}{3} \times 74 = 49{\cdot}33$.

The "expectation of life" of any community is the true test of the health of the community.

The hypothesis of De Moivre, as to the law of mortality, was that, of 86 persons born, one died every year until all became extinct. According to this hypothesis, it is an even risk that on the birth of a child it will live forty-three years, the chance of living or dying before that age being equal—forty-three being the half of eighty-six years. At age twenty there are sixty-six persons living; the half of sixty-six is thirty-three, which, as the deaths are equal in each year, is the expectation of life at that age.

The Rate of Increase in the Aggregate Population.—On what does it depend? Almost entirely on the *birth-rate* and *death-rate*, emigration and immigration appearing to have but little influence. The higher the birth-rate, and the lower the death-rate, the greater the increase. Hence, we have the "natural increment of the people" represented by the excess of births over deaths—the "actual increment" being of course only determined by the census.

A Stationary Population.—A population in which neither increase nor decrease takes place, the deaths being no more than counterbalanced by the births. Such a population would necessarily furnish materials for a life-table, but applicable only to itself.

Effective Population.—That portion of the community between the ages of twenty and seventy.

Absolute and Specific Population.—The absolute population is the total number of persons in any country; the specific population, the number of

persons to each acre, or square mile. The latter is the more important, as so much of the healthiness or unhealthiness of a locality depends upon the density of its population.

Population, and the Law of Increase.—Malthus propounded the proposition, that "*population, when unchecked, goes on doubling itself every twenty-five years, or tends to increase in a geometrical ratio;*" that is, in the following ratio—1, 2, 4, 8, 16, etc. He also came to the conclusion that the increase of food due to agricultural improvements, etc., advanced in arithmetical progression—thus, 1, 2, 3, 4, 5, etc. In both of these statements he has been found to some extent correct. Seeing the result of this, Malthus became alarmed; for he overlooked the effect of *free trade*, by which one nation is enabled to supply its wants from another, and also the new openings of colonial enterprise abroad.

It appears from Mr Lewis' digest of the census, that "population cannot increase indefinitely in London or elsewhere," and that although the population of London has shown at every census an increase, yet the rate of increase is gradually but surely declining. The probability, therefore, is that London has seen its maximum rate of increase.

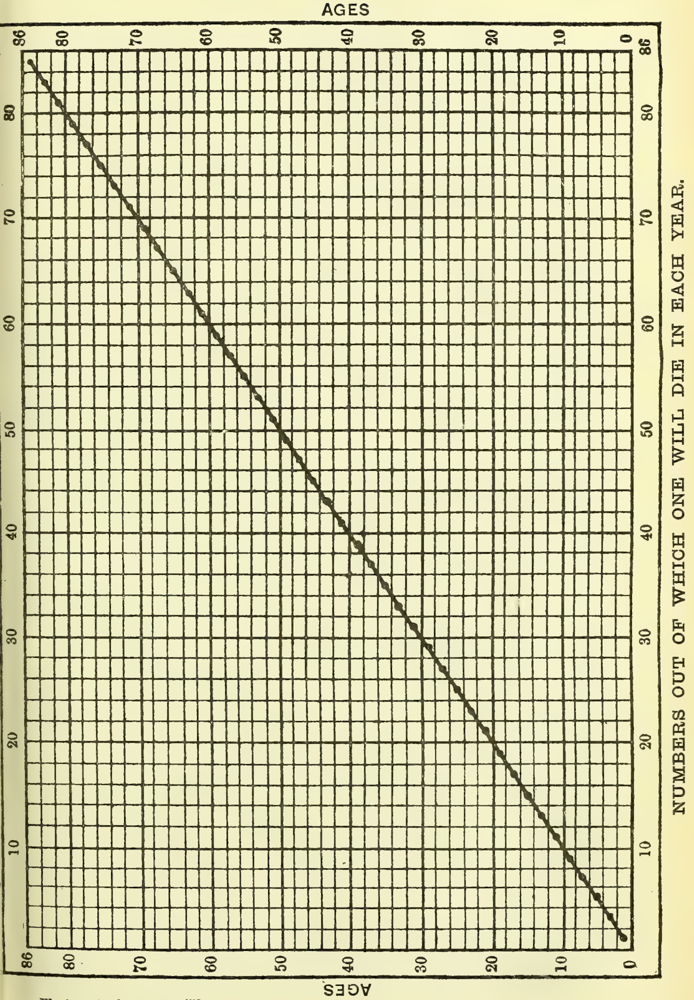
The rule for finding the rate of increase per cent. for a population which is found to double itself in a given number of years is as follows, and by way of example we select a population doubling itself in twenty-five years:—

Po = population at beginning of 25 years.

P_{25} = population at end of 25 years.

$$Po(1+r)^{25} = P_{25} = 2Po$$
$$(1+r)^{25} = 2$$
$$(1+r) = 2^{\frac{1}{25}}$$
$$= 1{\cdot}0281$$
$$r = 2\tfrac{8}{10} \text{ per cent.}$$

Of course, for 25, x may be placed for any number of years required.



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The checks to the increase of population are—

1. *Preventive* (*l'obstacle privitif* of Quetelet) :—

   (*a*) Late marriages. (*b*) Moral restraint during celibacy.

2. *Positive* (*l'obstacle destructif* of same writer) :—

   (*a*) *Vice*—Prostitution, violation of the marriage-bed, etc.
   (*b*) *Misery* — Overwork, unhealthy occupations, improper food, drunkenness, etc.

It may be noted here that prosperity does not always ensure a low death-rate. For ease of living, obtained by remunerative labour in growing industries, attracts numbers to the place; thence come overcrowding, impure water and air, generating the "camp diseases" by which the mortality is increased, for in all those places in which industries suddenly spring up sanitary requirements are, as a rule, at first neglected.

Value to be placed on the Registration of the Causes of Death.—Mr Neison, in a letter to the Registrar-General, insists on the importance of the following six items in the registration of deaths:—(1) Place, (2) Date, (3) Age, (4) Sex, (5) Employment, and (6) Cause of Death.

The value of life must necessarily depend much upon a variety of circumstances in various localities—such as occupation, liability to accident, habits, exposure to diseases, etc. It is well known that in several towns in the United Kingdom the rate of mortality varies exceedingly, doubtless from some of the causes above mentioned being more or less favourable to longevity; and Mr Neison's suggestion, therefore, points out the true way of arriving at the real value of life at different places.

Specific Intensity.—This term, when applied to the value of human life, represents the number living at any given age divided by the number dying at that age. Females have a higher intensity of life than males.

Normal Death-rate.—The normal death-rate appears to be about 11 per 1000. The causes that make the rate of mortality to vary are—(1) Causes inherent in the population itself, as *sex* and *age*. (2) Causes outside the population, such as air, water, food, clothing, oclesis, or density, etc.

Mean Age at Death.—The mean or average age at death of any given population is the sum of the ages at death divided by the number of deaths.

Is the mean age at death a safe measure and standard of comparison? The mean age at death can be employed with safety as a true test or measure only in those cases in which the calculation purporting to embrace an entire class is included, or in which the calculations embrace only a section of an entire class, the class in question is retained in a state of perfect uniformity during the whole time comprised in the calculation.

Different populations varying in their composition, and the same population, may in course of time undergo considerable changes, and exhibit striking contrasts in the number of persons living at different ages.

The mean age at death in France is 34; Sweden, 31; England, 40.

Climacterics.—It is a common belief that the years of age of human life produced by multiplying 7 into the odd numbers, 3, 5, 7, 9, are climacteric, and that the last is the grand climacteric. This is to some extent true; but it must be remembered that each man, according to his strength, has his own climacteric wave, but that the ages 21, 35, 49, 63, are only roughly correct. Forty-nine in women, and sixty-three in men, are critical years or periods. Like St Swithin's day, it is not the precise *day*, but that time of the year,

that if there be rain at all about that time, there may be a break of it.

Mean Duration of Life.—The mean duration of life is found by adding the age to the expectation of life. It is, in other words, the expectation of life at birth. The mean lifetime in England, under the most favourable circumstances, is 49 years; under less favourable conditions, 41 years.

In the case of individuals longevity and a high mean duration of life throughout the community are not the same. The proportion of persons of advanced age is no indication of a long lifetime generally, but depends greatly on the proportion of children. Due to there being less children in France the percentage of persons over 60 is greater than in England, yet life is longer in the latter than the former country.

Probable Duration of Life.—This is the age at which a given number of children born alive at the same time will be reduced one-half.

Birth-rate. — This depends upon the number of marriages and fertility of the women. The birth-rate is obtained by comparing the total number of births in a year, and the total estimated population at the middle of the same year; and is represented as the rate per 1000 of the population living in the district, at all ages, thus—

$$\text{Estimated population} : 1000 :: \text{births} : x$$

The illegitimate births are represented by a percentage of the total births.

Does a high Birth-rate involve a high Death-rate?—Not necessarily, for if the high birth-rate be natural and the result of prosperity and easy circumstances, the birth-rate will exceed the death-rate. But if the birth-rate be due to imprudent marriages or illegitimacy, the death-rate will be high.

Marriage-rate.—The number of persons marrying per 1000 of the population living in the middle of the year.

Normal or Standard Death-rate. — About 11 per 1000, but Dr W. B. Richardson would have it at 4 or 5 per 1000. In towns 17 per 1000 may be taken as a fair standard. The death-rate depends on the sanitary conditions of a community, and is therefore under legislative control, the birth-rate depends upon the action of individuals, and is therefore beyond the control of the State.

Zymotic Death-rate.—The total number of deaths occurring in a community during the year from small-pox, scarlatina, measles, diphtheria, whooping-cough, typhus, typhoid, relapsing fever, and diarrhœa.

Death-rate.—1. What is meant by death-rate or death-roll? The number of deaths occurring annually in every 1000 of the population.

2. From what data is it ascertained? From the Registrar-General's Annual Report of the Mortality of the United Kingdom. This, of course, only applies to the country taken as a whole. The death-rate of a *district* is determined from the actual or estimated population of the district. (See page 449.)

3. State approximately the mean death-rate of Great Britain. The average mortality in twenty-one years was 23·15 males and 21·58 females per 1000, the mean being 22·36.

4. State some of the leading causes which raise the death-rate of towns above that of rural districts.

(*a*) Overcrowding in towns. (See page 433.)
(*b*) Want of fresh air and pure water.
(*c*) Insufficient accommodation and drainage.
(*d*) Profligate and intemperate habits.
(*e*) Accidents.
(*f*) In London and other large towns many die in the hospitals who ought to be accredited to the country. The death-rate of

many watering-places is great only on account of the numbers who go for the benefit of health, but really to die.

Note.—The average mortality of a town is misleading, as the mortality of one district may be higher than that of another, and yet the average be very low. The Old and New Town of Edinburgh affords a proof of the above statement.

The death-rate is no criterion of the healthiness or unhealthiness of a place; and the late Dr Rumsey remarked that "a diminution in the rate of mortality will be found to co-exist generally with an augmentation of the rate of sickness. The very triumphs of advancing medical art are probably attended by an average prolongation of the helpless and infirm conditions of life." The highest ratio of sickness is sometimes found associated with a favourable rate of mortality (Neison).

The term *Morbidity* has lately been proposed to denote the amount of illness existing in a given community. It has been stated that the sick-rate of England and Wales is equal to the loss of 2,000,000 weeks, or the work of 2,000,000 men for one week per annum.

The death-rate of model dwellings for the poor is most probably fallacious, especially during the first few years of their tenancy; for as Dr Rumsey remarked, "the earlier inhabitants of these model lodgings would naturally belong to a better conditioned order of working people. Their selection of such dwellings would indicate the possession of a higher taste, greater frugality and temperance, and more adequate means of livelihood than the average of their class. Besides, the ratio of mortality in any small and isolated population, as I have before said, is, and must always be, a fallacious test of its ratio of unhealthiness."

Again, a low death-rate may be due to—(1) The preponderance of adult and selected lives in a district. (2) Trusting too implicitly to an average death-rate.

The results of sanitary measures are best seen from a low death-rate from infectious diseases, phthisis, etc.

5. How is the estimated population of a district obtained according to the method pursued by the Registrar-General?

(*a*) To the population of the district, as given in the last census, add a tenth of the difference between that number and the number obtained at the previous census for each year that has elapsed since the last census.

(*b*) The estimated population for the end of the first quarter of any given year, that being the period of the year at which the census is taken, is found by assuming that the increase during the ten years has been maintained at a steady progressive rate.

(*c*) The death-rate, however, is calculated on the estimated population of the district at the close of the second quarter of the year, therefore a fourth part of the annual increment, or a fortieth part of the actual increase of population which has taken place between the two censuses, must also be added to represent the increment for the additional quarter.

Thus, in a district where the population was found to be 36,000 in 1861, and 38,000 in 1871, the difference would be 2000; and this, divided by ten, would give the annual increase of 200. In 1876, five years would have elapsed since the last census; hence, the estimated population at the close of the first quarter of 1876 will be $38,000 + 200 \times 5$, and at the close of the second quarter it will be $38,000 + 200 \times 5 + 200 \div 4 = 39,050$—39,050 being the estimated population of the district for the year 1876.

The *actual* population can only be obtained from the census returns.

The following questions are of interest in this connection, and are of the *same nature* as those regarding the interest of money:—

Required the rate per cent. of increase of a population between two given periods.

Ex.—Population of L, 77,385 in 1801, and 100,749 in 1811.
Take the difference of these, which = 23,364.
Then, 77,385 : 23,364 : : 100 : 30·19, the rate required.

The population at one period being given, and the rate of increase per cent.; required the population at a former period.

Ex.—Population of L in 1811 was 102,987, and increased $24\frac{3}{4}$ per cent.; what was it in 1801?

Ans.—$124\frac{3}{4}$: 100 : : 102,987 : 82,555 (nearly).

LIFE ASSURANCE.

Life assurance is a contract by which a person, termed the *insurer*, in consideration of a sum of money proportioned to the risk, and technically called a *premium*, becomes bound to pay to the legal representatives of the *insured* at his death, or to the insured himself on his attaining a certain age, a sum of money previously agreed upon at the time of making the contract. Insurance is a consensual contract, but a written instrument on stamped paper is by statute requisite to its constitution.

There are three kinds of Life Insurance Companies—the Proprietary, the Mixed, and the Mutual.

In *Proprietary* Companies, a *fixed* sum is paid, the profits being divided only among the proprietors.

In *Mixed*, the insured participate in a portion of the profits, the rest being divided among the proprietors.

In *Mutual*, after paying expenses of management, the whole of the profits are divided among the insured.

Each of these modes of insurance has its advocates.

In an examination for life assurance, we have to investigate the physical condition, and the family and personal history of the individual proposed. The position of the medical examiner is by no means an easy one, for in the case of a life assurance examination the insurer is trying to appear at his best; whereas, in the ordinary examination of a patient, the patient is only too ready to describe every symptom. Tact will be required with regard to the use or abuse of alcoholic drinks, and the examiner will also have to consider the general appearance of the individual. Do the certified and apparent age correspond? Is premature baldness a family feature in the case, and does the history of longevity in the family contradict the apparent tendency to early degeneration? Do

his weight and height correspond? The above are some of the questions to be attended to, as regards the individual himself, but the examiner has also to investigate the nature of his surroundings and occupations. The unhealthiness of different trades and occupations is given on preceding pages, and these should be consulted. The following answers to questions relating to the life history of the family should be regarded with suspicion. Deaths are often attributed to the following causes :—"Caught a cold," "Child-birth," "Inflammation," "Dropsy." Investigate the nature of the "cold." How long after child birth did the death occur? The nature, seat, and duration of the inflammation. Phthisis may cause death after child-birth, but the death is referred to the delivery. Nature and cause of "dropsy" should be investigated and stated, and a careful examination made of the circulatory and urinary systems of the proposed "risk," as an insurer is sometimes technically called. Is there any impairment of vision? An ophthalmoscopic examination of the eyes may often reveal unsuspected renal or nervous mischief.

Albuminuria may be due to a variety of causes, and may be divided into two classes, *Transient* and *Persistent.*

Transient may be due to — (*a*) Forced exercise. (*b*) Severe mental strain in overworked students. (*c*) Cold baths. (*d*) Ingestion of large quantities of albuminous food—*e.g.*, eggs, etc.

Persistent may be due to—(*a*) Cases in which traces only of a albumen are found. (*b*) Cases in which a notable amount of albumen exists, and is always present. (*c*) Cyclic albuminuria in which a notable amount of albumen is found at one period of the twenty-four hours and none at another.

If the first group is correctly diagnosed, Dr Pavy does not consider the "risk" invalidated, but that in the second class the danger to life is invariably increased.

Albuminuria should, however, always be regarded as a "danger signal" in all applications for life assurance, and in persistent albuminuria, if the urine passed daily

exceeds 60 ounces, the risk should be rejected. If the specific gravity is high with absence of sugar, albuminuria is less significant than with a low specific gravity, which is always suspicious of renal disease. A specific gravity of 1010 is the lowest consistent with health. An extra premium is demanded by excessive obesity, and 25 per cent. extra is suggested by Dr Sieveking. Gout also demands careful consideration, and the usual rating up of three to five years is not sufficient. In cases of heart diseases a guarded opinion should be given, but they are not now regarded as the barrier to life assurance they were some years ago. Dr Sieveking would also add three years for a single hernia provided the patient wears a well fitting truss. With regard to phthisis the following will have to be considered :—

1. The preceding generations.
2. The collateral generations.
3. The descendants of the individual.
4. Has the insurer passed the age of 30 before which age most consumptives show signs of phthisis.
5. Was he born before either of his parents became phthisical? The collateral evidence is perhaps of more importance than the direct family history. Dr Theodore Williams has shown that phthisis in the mother gives rise to 5 per cent. more cases than when the father is affected, and in brother or sister to 50 per cent. more than phthisis in the father.
6. Is the occupation conducive to lung disease.
7. Has the proposed insurer passed the age at which his parents or brothers and sisters died?

In the young, stricture of the urethra demands an extra premium. An hereditary taint of insanity lessens the probability of life 20 per cent. The history of cancer in the family should be considered suspicious.

A person who is rated up 25 per cent.—

20 to 30	years of age add	10	years to life.
40 to 44	"	7	"
42 to 49	"	6	"
50 to 60	"	5	"

A "policy" is rendered void by the suppression of any *material* fact as affecting the life insured.

The whole system of life assurance is based on the probable duration of human life, and the value of the contributions of the members of the Society placed at compound interest.

Several methods have been proposed by which the probable duration of life may be approximately determined. These will now be noticed.

Life Table.—A life table is a table showing the probable duration of life. The first life table was the Breslau Table of Mortality, constructed by Dr Halley from the Registers of the town of Breslau, in Silesia, —no material being then available in this country, in consequence of the ages at death being unrecorded. This table was published in 1693.

Among other attempts in this direction may be mentioned Simpson's London Table of Mortality.

De Moivre's two Tables.

The Northampton, constructed by Dr Price.

The Carlisle Table, constructed by Dr Heysham.

The experience of seventeen Life Offices' Tables.

[The law of mortality may be best illustrated by the annexed Diagram, which may be used as an illustration of the graphic method of representing observations.]

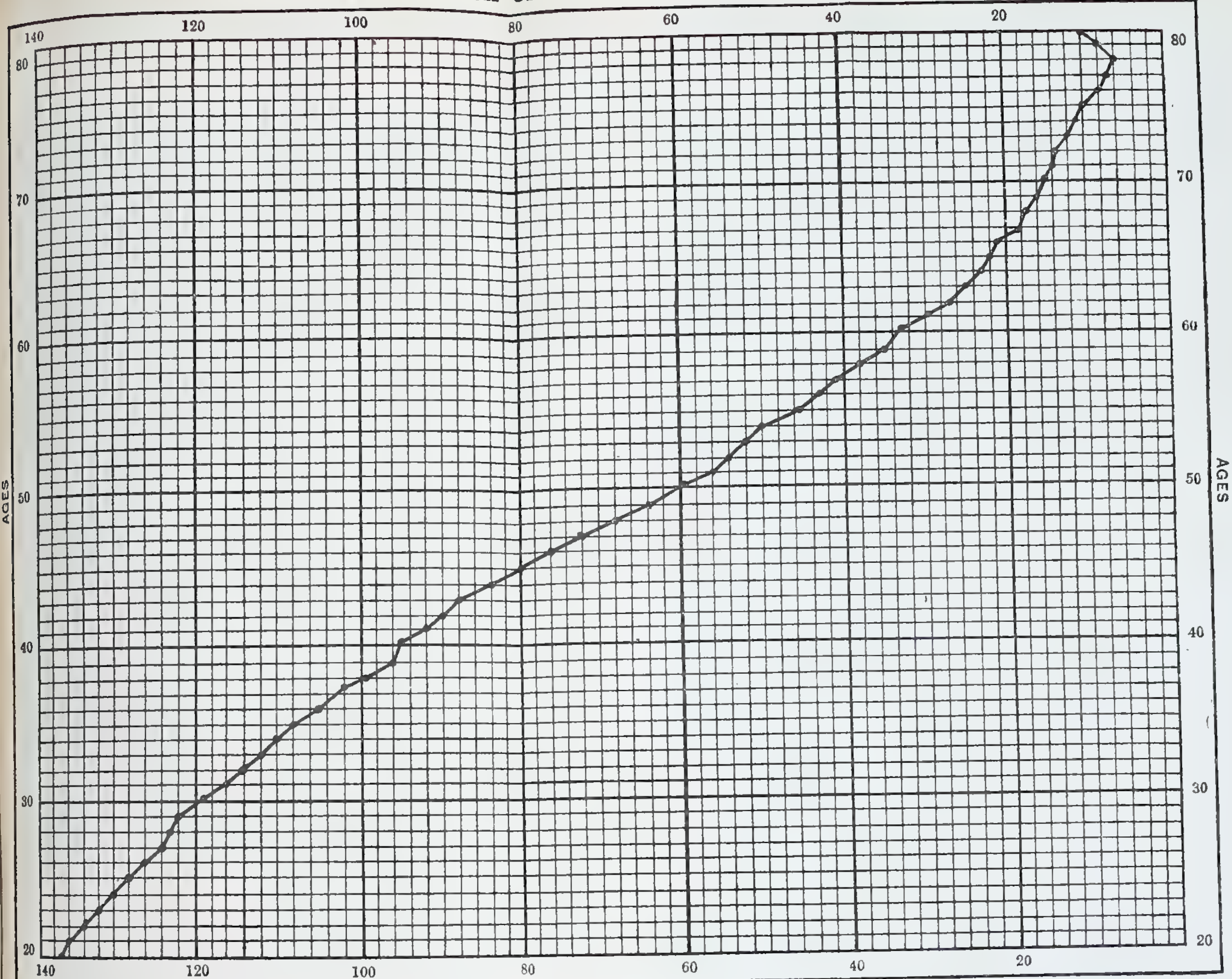
The English Life Tables of Dr Farr:—

1. Founded on a comparison of the *deaths* and the living at each age, giving the rate of mortality and survivorship.

2. Founded on the *deaths alone*, or with reference only to the ages at which the deaths have taken place. The former is the more correct and the more generally applicable; the latter is applicable if the population is stationary, the births and deaths equal, and no disturbing migration for a century.

The H. M. (healthy males) and H. F. (healthy females) Tables of the Institute of Actuaries of Great Britain.

NUMBERS OUT OF WHICH ONE PERSON WILL DIE IN EACH YEAR.



NUMBERS OUT OF WHICH ONE PERSON WILL DIE IN EACH YEAR.
Drawn from the "Experience of Seventeen Offices" Table.

Electro—to face page 464.

AIR.

The atmosphere is the gaseous envelope which surrounds this earth. Its height has been estimated at from 30 to 40 miles, but from the observations of meteorites a height of 200 miles has been assumed.

The atmosphere consists of a mechanical mixture of two gases—oxygen and nitrogen. This is shown from the following:—

1. The amounts of oxygen and nitrogen in the atmosphere are not in their combining proportions.
2. When mixed in the proportions found in the air, no contraction in volume or evolution of heat is noticed.
3. Water takes up unequal portions of the two gases, according to the law of absorption of gases, in liquids.

The oxygen is the active agent in supporting animal life and promoting the combustion of bodies; the nitrogen acts simply as a diluent, and modifies the activity of the oxygen. The proportion of oxygen to nitrogen is as 1 to 4; or by volume, nitrogen 79·19, oxygen 20·81; by weight, 76·90 and 23·01 respectively. The air collected by Martins on the Faulhorn, at a height of 8226 French feet, had not less oxygen than the air of Paris. More recent investigations have shown that often the oxygen at great elevations is less than at lower levels. This has been ascribed not to diminution of oxygen in the upper levels, but to an increase in the lower from the fixation of carbon and liberation of oxygen by plants. On the other hand, it has been found that CO_2 increases with height; and Smith suggests that the organic substances floating in the air become oxidised; hence, the diminution of oxygen with increase of CO_2 as just stated. Hence, mountain air appears to contain little or no organic matter, and more CO_2 and less oxygen than lowland air. It has been proposed to take the percentage of oxygen as a test of purity, "very bad air beginning at 20·6" (Smith).

But owing to the escape of the products of combustion, of respiration, and the decay of animal and vegetable substances, the atmosphere also contains aqueous vapour, carbonic acid, ammonia, organic matter, salts of sodium, etc.

The amount of carbonic acid varies from ·02 to ·05 per cent., or ·2 to ·5 per 1000, and is due to the respiration of animals, the interior of the earth in districts of extinct volcanoes and thermal springs, and the decomposition of the small portion of carburetted hydrogen existing in the air by the electric discharges of clouds (HUMBOLDT). To these we may add the combustion of carbonised materials. The air collected above the ocean shows a small variation in carbonic acid between day and night, the proportion being 5·4 for the former, and 3·3 for the latter, in 10,000 volumes of air; this being probably due to the increase of the co-efficients of absorption with decrease in temperature during the night.

Ozone.—Ozone, an allotropic form of oxygen, appears from modern researches to be condensed oxygen in which three volumes are condensed into two, one of the volumes being, however, in a different polar condition to the other two $\left(\overset{-}{0}\,\overset{+}{0}\,\overset{-}{0}\right)$. It possesses powerful chemical activity as an oxidising agent, and in this is superior to oxygen. It may be developed artificially by passing electric discharges through air or damp oxygen; by the slow oxidation, *eremacausis*, of phosphorus in air; by the electrolysis of water acidulated with sulphuric acid—and by the action of three parts of strong sulphuric acid on two parts of potassium permanganate aided by heat. Its chief source is atmospheric electricity, and is the cause of the supposed sulphurous smell said to accompany thunderstorms. According to the late Dr Tidy—

1. More ozone is present during the night than during the day, and most is found at daybreak.

2. More is found in winter than in summer, and least in the autumn.
3. More is found at high than low levels.
4. More is found on the sea-coast, especially when the wind is blowing from the sea, than inland.
5. More is found in the country than in towns.
6. More is found after a thunderstorm than at any other time ; least of all is found on damp or foggy days.
7. More—in England—is found with western than with eastern winds.
8. The maximum quantity in the air never exceeds $\frac{1}{700000}$ part of its bulk.
9. Seldom found in the air of inhabited rooms.

Ozone has the property of bluing starch paper treated with iodide of potassium, by setting free the iodine. This change may also be affected by chlorine or any nitrous acid present in the atmosphere. A better test —Houzeau's ozonometer—is the bluing of litmus paper slightly reddened and impregnated with iodide of potassium ; ammonia being the only gas which has a similar reaction. But this source of error may be obviated by noticing that reddened litmus paper, not impregnated by the iodide, is blued by ammonia, but not by ozone. Its presence may be roughly estimated by exposing strips of paper prepared as above for a given time, and noting depth of colour produced. Standard shades of colour may be used for comparison. Ozone is said by Schönbein, its discoverer, to destroy organic matter floating about in the air of a room. On the air passages it causes severe irritation, and its excess in the air has been suggested as a cause of influenza and other respiratory troubles.

THE IMPURITIES OF AIR.

The chief source of the vitiation of the air round dwellings is most probably due to the dampness of the ground surrounding them, and the presence of liquid filth washed into the soil by rain from heaps of rubbish carelessly placed round them.

The impurities of air may be classed under two heads—

(1) Suspended Matters.

(2) Gaseous Substances.

1. Suspended Matters. — The spores of certain plants, the germs of bacteria and other creatures, particles of carbon from factories, and portions of the materials used in certain industries, together with a host of other substances which find their way into the atmosphere and are carried from place to place by the winds. The phenomenon known as a *dry fog* is the result of a dry and stagnant state of the atmosphere, during which the air becomes filled with dust and smoke. In 1783 a dry fog prevailed over Europe, and lasted for more than a month. It was preceded by a remarkable eruption of the volcano Hecla, in Iceland. The sand which sometimes falls on the Cape Verd Islands, to which attention was directed by Darwin, was found by Ehrenberg to contain innumerable silicious-shelled infusoria.

If the air outside our dwellings be thus loaded with impurities, how much more impure must that air become in closed, ill-ventilated rooms, where to the above are added the exhalation from the lungs and skin, and the effluvia from discharged secretions!

In sick-rooms, and in the wards of hospitals, where the ventilation is imperfect, the air has been found to contain organic matter to such an amount that a portion collected and burnt gave out an odour of burnt horn. The discovery of a peculiar fungoid growth in a cholera ward in 1849 by Drs Britain and Swayne, and the presence of which subsequent observers have corroborated, has led to a more careful examination of the air of our hospital wards, with the most valuable results to medicine and pathology.

To the exhalation of diseased particles from the lungs of persons suffering from phthisis may the explanation

come of those cases of apparently communicated consumption. The bacterial origin of phthisis is now being hotly discussed. Of course, as all persons are exposed to the like influences with regard to the purity or impurity of the air they breathe, the assumption of an individual predisposition to disease is rendered necessary; but as we can seldom be certain beforehand of the presence of such predisposition, the necessary precautions to insure the purity of the air are the more imperative.

Dr Tilbury Fox, some years ago, related to the London Medical Society the account of a discovery he had made of the presence of the mycelium of the trichophyton in the air of a ward where a number of children suffering from tinea circinata were placed. The dust was collected on glass slides, moistened with glycerine, and then examined under the microscope.

The escape of particles of arsenic from the "rich green-flock" papers still used for house decoration has resulted in several cases of arsenical poisoning, and in one or two cases with a fatal issue.

In workshops and factories, in most cases, to the ill effects of bad ventilation and over-crowding, are added the emanations from the materials in varying stages of manufacture. The dust of grinding shops has been found to contain large quantities of iron in very minute particles, which, by being constantly inhaled, produces the disease well known as *grinders' rot.*

In "coal-miners' phthisis," the sputa is often quite black from the particles of carbon introduced into the lung during respiration. The wearing of respirators by the men engaged in trades where the production of a large amount of dust is unavoidable, has been suggested; but workmen are a heedless and stubborn class of men, and are little prone to do anything which requires a little trouble, or the smallest amount of fancied inconvenience.

2. Certain Gaseous Substances.—Hydrochloric acid from alkali works, ammonia, sulphuretted hydrogen from ammonia and other chemical works, sewage gases, carburetted hydrogen, vapours from decaying animal and vegetable bodies, from slaughter-houses, bone-boilers, glue-makers, soap-boilers, etc. Certain poisonous fumes from copper smelting works, brass-founders, etc.

Diseases Caused or Increased by Impure Air.—Phthisis, typhus, grinders' and miners' phthisis, a form of chronic bronchitis, granular conjunctivitis, hospital gangrene, pyæmia, erysipelas, malaise, or a feeling of being ill without the presence of any specific disease.

THE PURIFICATION OF AIR.

Besides the purifying effect of ventilation, other methods are adopted to render air fit for human respiration, but these must only be considered as supplementing, not superseding, ventilation. The materials used may be either solid, liquid, or gaseous.

1. Solids.—Certain substances act chemically on air; thus, charcoal is used to purify the air issuing from drains and cesspools. Of the kinds of charcoal used, animal appears to act the best; then that made from peat. The charcoal, from whatever source, should be kept very dry to ensure its constant activity. Unslacked lime is used to absorb carbolic acid in wells, etc. Sulphate of copper removes the odour of sulphuretted hydrogen. The ferrous sulphate is also useful in treating the stools of typhoid fever.

2. Liquids.—A solution of nitrate of lead will remove the sulphuretted hydrogen from cesspools. Solution of chloride of zinc (Sir W. Burnett's Fluid) destroys organic matter. Solution of permanganate of potash (Condy's Fluid) destroys organic matter, decomposes ammoniacal compounds, and absorbs

sulphuretted hydrogen. Chromic acid, prepared by adding sulphuric acid to bichromate of potassium, is held by Smith to be a most important sanitary agent as an antiseptic.

3. Gases and Vapours.—*Nitrous Acid.*—Acts on organic matter, but it must be used with care, as it may in some persons cause severe irritation in the lungs.

Chlorine.—Decomposes the sulphide of ammonium and sulphuretted hydrogen, and destroys animal matter in the air.

Sulphurous Acid.—Destroys organic matter, and, according to Guyton de Morveau, it destroys miasms.

Carbolic Acid.—Hides other odours, arrests putrefactive changes and the growth of fungi, but does not appear to have the power of ultimately destroying them. It is probably more of an antiseptic than a disinfectant. The diluted acid has been found a valuable dressing for wounds.

Iodine Vapour. — Arrests putrefaction, but it is inferior to chlorine, as it is not so diffusible, and condenses readily.

Bromine Vapour.—Should be used with care, as the vapour is very irritating.

Euchlorine. — Prepared by heating strong hydrochloric acid and potassium chlorate in a saucer. Acts like chlorine, but is less irritating to the lungs.

THE EXAMINATION OF AIR.

The air should be collected, in clean glass jars, holding about a gallon. This may be done by blowing in the air with a pair of bellows, the nozzle of which must reach to the bottom of the jars.

Substances to be looked for—(1) Suspended Matters. (2) Organic Matter. (3) Carbonic Acid. (4) Watery Vapour. (5) Ammonia.

1. Suspended Matters—Detected by the microscope, the air being previously drawn through an aspirator over glass slides moistened with glycerine, which collects all the solid matter suspended in the air.

Pouchet's Ærescope.—Its construction is very simple, consisting of an air-tight chamber with two openings, into one of which is fitted a small funnel, the stem of which is drawn into a fine point; into the other, a glass tube connected to the aspirator by india-rubber connections. A glass slide moistened with glycerine is placed in a box, so that the air drawn through the funnel may impinge upon it. The slide may then be placed under a microscope and examined.

Dr Parkes objects to the use of glycerine on account of the difficulty of procuring it perfectly free from foreign particles. He recommends the following plan :—A small bent glass tube is taken, carefully washed and dried, and then heated to redness; when cool it is inserted in a freezing mixture, and one end attached to an aspirator by a piece of india-rubber tubing. The air is then slowly drawn through, and the moisture of the air containing the suspended matter is condensed; a drop may be then placed on a slide and examined as in the former case.

An aspirator may be made by procuring a box of a known capacity (*i.e.*, one cubic foot), with openings in it like that used by Pouchet, to contain the slide, but, in this case, filled with water. As the water is allowed to run out at one aperture, air rushes in at the other, and if this be attached to the box containing the slide, or to Parkes' bent tube, air will be drawn through them. In every case the air should be drawn very slowly through the aspirator.

2. Organic Matter.—Determined by a solution of permanganate of potash, through which a definite quantity of air is drawn, and the amount of undecomposed potassium permanganate determined by oxalic acid. This process does not admit of satisfactory results, as it only indicates the amount of oxidisable matter present in different samples of atmospheric air, without giving any indication whence this oxidisable matter is derived, whether from animal or vegetable substances. Nitrous, sulphurous, and other acids present in the air produce the same reaction, thus rendering the test useless as to the actual presence of *organic* matter.

Mr Moss proposes the following mode of procedure :—A known quantity of air is drawn through four bottles containing pure water free from ammonia ; to the contents of the first of the series 5 C.C. of pure hydrochloric acid are added. The contents of the flask are then examined on Wanklyn's plan for free and albuminoid ammonia.

3. Carbonic Acid.—Degree of milky colouration, with a standard solution of lime or baryta water.

Dr Angus Smith's Method.—A clean wide-mouthed stoppered bottle, capable of holding seven ounces, is taken, and air drawn into it by means of a glass tube, care being taken not to breathe into the bottle. Put in half-an-ounce of clean baryta water (·08 of a gramme of baryta), close the bottle, and shake. If the air should contain less than ·03 per cent. of CO_2 there will be no precipitate. Lime water may be used instead of baryta water, but in that case the bottle must be larger, owing to the greater solubility of carbonate of lime, and the consequent difficulty in recognising the beginning of opacity. In using lime water a graduated pipette is necessary to draw out the required half-ounce of lime water.

The following Table will best explain the process :—

Air at 0° Centigrade and 760 m. m. Barometer.

Carbonic Acid in the Air.	Size of Bottle to be used with half-an-ounce of Lime Water, no precipitate produced.
·03 per cent.	20·63 oz. avoirdupois.
·04 "	15·60 "
·05 "	12·58 "
·06 "	10·57 "
·07 "	9·13 "
·08 "	8·05 "
·09 "	7·21 "
·10 "	6·54 "
·15 "	4·53 "
·20 "	3·52 "
·25 "	2·92 "
·30 "	2·51 "
·50 "	1·71 "
1·00 "	1·10 "

Dr Smith proposes the following rule as a practical application of this method :—Let us keep our rooms so that the air gives no precipitate when a $10\frac{1}{2}$ oz. bottleful is shaken with half-an-ounce of clear lime water.

Pettenkofer's Method.—Take a glass vessel capable of holding from half a gallon to a gallon and a half, and determine its exact capacity by filling it with water and measuring the contents by means of a pint measure, 1 ounce = 1·733 cubic inches. The vessel should be carefully dried, and then filled with air, by means of a pair of bellows, taking care that the nozzle of the bellows reaches the bottom of the jar. When full, pour in rapidly 60 C. C. of clear lime, or baryta water (pure baryta, 7 grammes; water, 1 litre); cover the mouth of the jar with an india-rubber cap, shake well so that the liquid may flow over the sides, and then set it aside for not less than six or eight hours or more

than twenty-four. By the absorption of the carbonic acid by the lime or baryta water, the causticity of these fluids is lessened, and on this fact the test depends, for if the causticity of the lime solution be known both before and after the experiment, the amount of CO_2 can be calculated.

A solution of crystallised oxalic acid is used to determine the causticity of the lime, the strength of which should be 2·25 grammes of pure crystallised oxalic acid to the litre of distilled water. Now take 30 C. C. of the lime or baryta water from the jar, and carefully neutralise it by running in from a graduated burette the standard oxalic acid solution. The exact point of neutralisation is determined by dropping from time to time a drop of the liquid on turmeric paper. The stain produced before the addition of the oxalic acid is of a dark brown colour, but as the oxalic acid is run in, the centre of the drop becomes gradually free from colour, and only the margin appears of a delicate-brown shade. Care must now be taken only to drop in very small quantities at a time till the coloured margin also disappears, when the point of neutralisation is reached.

Having determined the causticity of the lime solution in the jar, next determine the causticity of the original lime water, and then multiply the difference between the two quantities by 790, and divide the product by the number of cubic centimetres contained in the jar *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes. Care should be taken that the baryta water be absolutely free from potash or soda. A correction must be made for temperature.

Wilson gives the following simple rule :—For every 5° above 62° F. add one per cent. to the amount of CO_2, calculated as above, and deduct the same for every 5° below 62° F.

In ordinary cases, the barometric pressure may be omitted, but if it be required to examine the air at any considerable height, adopt the following :—

$$\text{Standard height of barometer (30 inches)} : \text{observed height} :: \text{capacity of jar} : X$$

The result expressed by X is substituted for the actual capacity of the jar in the previously mentioned calculation for CO_2.

4. *Watery Vapour.*—Determined by various forms of hygrometers. A healthy amount of moisture and heat is shown when the dry bulb thermometer stands at 60° F, and the moist bulb about 55° F. The difference should not be less than 4° or more than 8°. (See page 479.)

5. *Ammonia.*—To perform this test, the air must be drawn through distilled water, previously tested as to its freedom from ammonia. (See account of the Nessler Test, page 606.)

AIR VITIATED BY RESPIRATION.

The effect of respiration is to increase the amount of carbonic acid and watery vapour in the air of a room, and also to add to it a varying quantity of certain undefined organic substances, at the same time that the oxygen previously present is rapidly decreased in volume. The organic matters blacken sulphuric acid, and decolourise permanganate of potash in solution.

Dr De Chaumont, quoted by Denton, states that "an assemblage of 2000 persons will give off in two hours (in vapour) seventeen gallons of water, and nearly as much carbon as would be extracted from a hundred-weight of coals." The amount of watery vapour from lungs and skin has been estimated at thirty ounces per diem for each individual.

According to Parkes, an adult man in ordinary work gives off in twenty-four hours from twelve to sixteen

cubic feet of carbonic acid gas from his lungs, besides a certain undetermined quantity from his skin. On an average, an adult man, not doing excessive work, may be considered to give to the atmosphere every hour ·6 cubic feet of CO_2. It is found that when this gas reaches ·7 per 1000 volumes, the organic matter is in most cases perceptible to the sense of smell, and that the odour is more pronounced when the CO_2 amounts to 1 per 1000. The amount of CO_2 present in a room may be taken as an index of the organic impurity of the air vitiated by respiration alone; for it is found that the organic matter increases as the CO_2 is increased, especially if the heat of the room be not excessive.

AIR VITIATED BY FIRES AND LIGHT-PRODUCERS.

The products of combustion from fires for the most part escape up the chimney, and by this means into the open air; but this is not, as a rule, the case with the products formed by gas, oil-lamps, or candles used for the production of artificial light. One hundred cubic feet of gas in combustion destroys eight hundred cubic feet of oxygen, with the production of about two cubic feet of carbonic acid gas, and also raises the temperature of 31·290 cubic feet of air 100° F. An ordinary burner burns from three to four cubic feet of gas per hour, and as it has been calculated that for every cubic foot of gas burnt at least 1800 cubic feet of air should be introduced, we are able to calculate the amount of air required per burner and per hour. When the combustion of the gas is imperfect, 67 per cent. of N, 16 per cent. H_2O, 7 per cent. of CO_2, and 5 to 6 per cent. of CO, with varying amounts of H_2SO_3 and NH_3, are thrown into the atmosphere. An ordinary moderator lamp, burning 154 grains of oil per hour, takes from the air of a room 3·2 cubic feet of oxygen, with the production of about half a cubic foot of CO_2 per hour. One pound of oil

for its complete combustion will require from 138 to 160 cubic feet of air; and as much air must be introduced for one pound of oil as for ten feet of gas. Dr Odling states that, for equal illuminating power, candles yield a larger amount of impurity to the air than gas, and that two candles have the same effect on the air as one man. A candle of six to the pound burns about 170 grains per hour. The combustion of three cubic feet of gas per hour renders 3600 cubic feet of air impure. A burner of this description vitiates more air than three adult persons. The combustion of 1000 tons of coal will send about fifteen tons of sulphur into the air as sulphurous acid. The coal consumed in Glasgow and its vicinity is said to give off about 300,000 tons of sulphuric acid annually. In London, 5,000,000 tons of coal are burnt every year, equal to 75,000 tons of sulphurous acid.

VENTILATION.

The importance of a knowledge of the principles of ventilation cannot be over-estimated, yet there is probably no branch of knowledge over which so much erudition is expended, and so little really accomplished. A knowledge of the principles of ventilation implies an intimate acquaintance with the general properties of gases and vapours, the nature and composition of atmospheric air, and the changes to which it is subject from the effects of the respiration of animals, the modifying influences of vegetation and climate, and the results of the combustion of certain bodies either to produce artificial heat or light.

General Properties of Gases and Vapours.

A *gas* is an aeriform body characterised by a marked tendency to occupy a larger space; and hence, it has neither an independent form nor an independent volume. Oxygen and hydrogen have of late been

liquefied, thus effacing the old distinction between permanent and non-permanent gases. Professor Dewar has just succeeded in liquefying air.

A *vapour* is also an aeriform body, differing from a gas in its comparatively easy reduction to a liquid condition—the vapour of water.

Law of Diffusion of Gases and Vapours.

Gases differ from liquids in this, that, if gases of varying density be poured into a tall jar, in a short time the mixture in every part of the jar will be the same; whereas in liquids, the lighter will be found at the top, and the heavier at the bottom; and this mixture of gases will take place even through animal membranes or considerable thicknesses of any porous material. If two jars be taken, one containing hydrogen and the other oxygen, separated by a layer of plaster of Paris, and so filled that the lighter hydrogen be placed above the heavier oxygen, an interchange of gases will take place; which may be proved by an explosive compound being formed, and which, on the application of a match, will go off with a loud report. The passage of an electric current through the mixture will also cause an explosion with, as in the former case, the production of water—thus showing that the previous mixture of the gases was a purely mechanical one.

The following laws should be remembered :—

Boyle's or Mariotte's Law.—The law is as follows :—*The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure which it bears; or, for the same temperature, the density of a gas is proportional to its pressure.*

This law has of late been shown to be only approximately true, for Regnault found that air does not exactly follow Boyle's law, but experiences a greater compressibility, which increases with the pressure; so that the difference between the calculated and the

observed diminution of volume is greater in proportion as the pressure increases. Non-saturated vapours obey Boyle's law, but saturated vapours are incompressible, a portion being liquefied with any increase of pressure, and the tension which is left in the state of vapour remaining constant.

The correction of gases for pressure and temperature may be made by the following formula :—

X = final volume.
a = volume of gas.
H = original pressure.
h = final pressure.
T = original temperature.
t = final temperature.

$$X = \frac{a \times H\,(273 + t)}{h\,(273 + T)}$$

Example.—What volume will 50 cubic feet of air, measured when the temperature is 15° C. and barometric height 30 inches, occupy when the temperature becomes 25° C. and the barometric height 28 inches.

$$x = \frac{50 \times 30\,(273 + 25)}{28\,(273 + 15)} = 55{\cdot}43$$

Nitrogen closely resembles air, but CO_2 shows considerable deviation from the law, even under small pressures.

Charles' Law.—*The volume of a gas is directly proportional to its absolute temperature, reckoned from its absolute zero, that is, 273° C. below 0° C.*

Thus 273 volumes at 0° C. become
274 " at 1°
275 " at 2°

Also 273 volumes at 0° C. become
272 " at 1°
271 " at 2°
270 " at 3°

The absolute zero is that degree of cold which ceases to affect a gas as cold usually does.

GRAHAM'S LAW.—*The ratio of diffusion of gases is inversely proportional to the square roots of their relative weights or densities.*

To find the specific gravity of a gas, divide the weight of the gas by the weight of an equal quantity of hydrogen, or air, whichever be taken as a standard. For example—

A glass globe	full of air	weighs	1272·67
"	full of CO_2	"	1279·27
"	empty	"	1260

1272·67 − 1260 = weight of air 12·67
1279·27 − 1260 " CO_2 19·27

19·27 ÷ 12·67 = 1·52 sp. gr. CO_2

From the experiments of Feddersen of Leipzig, it appears that when a porous substance acts as a diaphragm between the same gases, the pressure on each being the same, the passage of the gas takes place from the cold to the warm side. Having acquired an insight into the laws which thus govern atmospheric changes, we are now in a position to apply them, so as to enable us to supply a due and appropriate quantity of pure air to any apartment, passage, or other cavity to which the external air has not free and unlimited access.

In considering the question of ventilation, there are three important points to be borne in mind—

1. The capacity of the room—that is, the amount of cubic space which it contains.

2. The number of individuals normally present in it.—*An allowance must also be made for the number of gas-jets, lamps, candles, fire-places, etc.*

3. The efficiency of the means for introducing pure air, and allowing the vitiated to escape.

1. The Capacity of the Room, etc.

In calculating the cubic space of any given apartment the height, length, and breadth must be multiplied together, allowance being made for any recesses, cupboards, and also for the bodies of the occupants, an average of three cubic feet being allowed for each individual. The weight of a man in stones divided by 4, gives the cubic space occupied by him. The space occupied by articles of furniture must also be considered. If the room be irregular in shape, it must be divided into several imaginary triangles or squares, the sum of which will give the size of the room. After these various corrections, the remaining number of cubic feet divided by the number of individuals will give the cubic space per head. It must be borne in mind that the purity of the air in a room does not depend upon its size, but on the rate at which impurities are produced, and the rate at which fresh air can be introduced without producing draughts.

Measure in feet and decimals of a foot. Convert square inches into square feet by multiplying by ·007.

Area of a Triangle	=	Base × ½ height, or $B \times H \div 2$, or $H \times \frac{1}{2} B$.
Area of a Circle	=	$D_2 \times \cdot 7854$, or $C_2 \times \cdot 07958$, or $\frac{1}{2} C \times \frac{1}{2} D$.
Area of Rectangle	=	Multiply two sides.
Area of Parallelogram	=	Multiply a side by its width on the square.
Area of Trapezium	=	Multiply the diagonal by the sum of the two perpendiculars falling upon it from the opposite angles, and divide the product by 2, or divide into any number of convenient triangles, and take the sum.
Area of Trapezoid	=	Take one-half the sum of the parallel sides, and multiply by the distance between them.

CUBIC CONTENTS.

Cubic contents of a Cone	= area of base	× $\frac{1}{3}$ height.	
" " *a Cylinder*	= "	× height.	
" " *a Dome*	= $\frac{2}{3}$ area of base	× height.	
" " *a Sphere*	= D_3 × ·5236.		

The cubical capacity of a marquee, used as a provisional hospital, may be found by dividing it into—

(1) *Body*—A solid rectangle, with a half cylinder at each end.
(2) *Roof*—Solid triangle and two half cones.

The minimum amount of space allowed by the Poor Law (Local Government) Board in dormitories is 300 cubic feet, which, to allow 3000 cubic feet of air for each person, necessitates that the air be changed at least ten times during the hour.

2. Number of Individuals Normally Present.

When the number of persons occupying a room sought to be ventilated is always the same, there can be little difficulty in supplying the proper amount of pure air per head; but when the numbers are constantly subject to change, considerable difficulty may be experienced in making the necessary arrangements to supply the varying demand. This was one of the difficulties with which Dr Reid had to contend in his proposal for ventilating the Houses of Parliament. Putting aside this difficulty, it may be stated in general terms that sufficient air should be supplied to each individual, so that the amount of carbonic acid present in the air of the room should not exceed ·6 per 1000 volumes, the amount of carbonic acid present being taken as the index of the organic impurity, allowance being made for ·4.CO_2 naturally existing in the atmosphere.

Air required by Individuals.—Three to four cubic feet of air are required by each individual per minute. Windows, as usually constructed, will admit about eight cubic feet per minute.

To find the number of persons who may occupy a room.—Multiply the height, length, and breadth of the room together, and divide by the number of cubic feet of air proposed to be allowed for each person. Thus—

$$10 \times 20 \times 10 = 2000 \div 400 = 5$$

To calculate the quantity of fresh air required per hour for each individual :—

$$y = \frac{k}{p - q}$$

y = volume of air required.
k = volume of CO_2 produced by persons, lights, etc.
q = proportion of CO_2 to be allowed to reach volume of air.
p = proportion of CO_2 existing in normal air.
p = ·0007 per volume of air.
q = ·00037 per volume in normal air, or ·0004 per cubic foot.

The value of p and q varies with different writers.

The following formula of Dr De Chaumont may also be used :—

R = the ratio of CO_2 normally in the air (*i.e.*, ·0004 per cubic foot).
r′ = the additional ratio per cubic foot of air of vitiation by respiration of one male adult in an hour (the average being ·6 cubic foot of CO_2).
r = the ratio per cubic foot of air to which it is desired r′ should be reduced.
c = the capacity in cubic feet of the air space.
d = the delivery of fresh air in cubic feet.
v = the entire volume of the air—viz., c + d

The formula is—

$$\frac{r' - R}{r - R} \times c = v \text{ and } v - c = d$$

Or v may be eliminated thus—

$$\frac{r' - r}{r - R} \times c = d$$

3. Efficiency of Means for introducing Pure Air, and allowing the Vitiated to Escape.

(*a*) The entering air must be pure, of a proper temperature, and supplied at the rate of 3000 cubic feet per head per hour.

(*b*) There should be no draught.

The rate at which air moves through a room depends on the differences of temperature between the internal and external air, and the efficiency of the mechanical means adopted for drawing the air through the room. A velocity of from 1 to 2 feet per second, at a temperature of 60° F., will not cause a draught, and will yet answer the purpose of ventilation. The velocity should not be more than 19 inches, or a little more, per second; it is better to enlarge the channels. A draught is produced if the air be changed oftener than six times an hour, or if the velocity be from 3 to $3\frac{1}{2}$ feet per second. A draught is the one-sided cooling of the body, or some part of it, by cold air in motion, or by increased one-sided heat radiation. As a result, there is a local perturbation of our heat economy, the cold air acting on the nerves which regulate the calibre of our blood-vessels.

(*c*) The air must be diffused through the room; in no part ought it to remain stagnant.

(*d*) There must be means provided for the escape of the foul air, and entrance of the pure.

To calculate the size of outlets or inlets of air:—

$$\frac{D}{100\sqrt{H(T-t)\times\cdot 002036}} = \theta$$

D = delivery required per hour. H = height of heated column of air. T = temperature of column. t = temperature of external air. θ = area of outlet and inlet in square inches. ·002036 = ratio of expansion for 1° F. 100 = a constant.

To calculate the delivery per hour, the area of inlet being given:—

$$D = 200\left(\sqrt{H(T-t)\times\cdot 002036}\right)\theta$$

200 = constant, obtained by multiplying the number of seconds in an hour by twice $\sqrt{16\cdot 09} = 8$ nearly, and dividing by 144 square inches. θ = area of inlet. H, T, t, as in preceding formula. (De Chaumont.)

NOTE.—In England, 24 square inches of outlet and inlet per head is sufficient.

$$\pi = p + \frac{P}{A} \qquad \text{or} \qquad A = \frac{P}{\pi + p}$$

p = CO^2 in a cubic foot of pure air.
P = CO^2 from each individual per hour.
A = cubic feet of air introduced per hour, the same escaping by outlets.
π = permanent or resulting impurity.

$$p = \cdot 0004 \qquad \pi \; \cdot 0006$$
$$P = \cdot 6$$

It may be as well to note here the results of Pettenkofer on the permeability of brick walls, and the passage of air through them :—

The room had brick walls, and contained 2650 cubic feet. With a difference of temperature of 34° F. (66° inside and 32° outside), the air in the room was changed once, equal to 2650 cubic feet. With the same difference, but with a good fire and a free vent up the chimney, the change of air rose 3320 cubic feet, or about 25 per cent more. With all the openings and crevices pasted up, there was still a change of 1060 cubic feet, or a fall of 28 per cent. With a difference of temperature of 7° F. (71° inside and 64° outside), the change amounted to only 780 cubic feet per hour. With a window open of 8 square feet, the change was 1060 cubic feet per hour. Thus, a difference of temperature of 34°, with carefully shut windows and crevices, is of greater influence than large communications with the outer air at a small difference of temperature.

Marker and Schultze have found that the spontaneous ventilation through one square yard of the following substances, with a difference of 4° F., amounted per hour :—

Sandstone, ...	to 4·7	cubic feet.
Quarried Limestone, . . .	to 6·5	"
Brick, ...	to 7·9	"
Turfaceous Limestone, . . .	to 10·1	"
Mud, ...	to 14·4	"

DIRECTION AND MOVEMENT OF AIR.

The direction or movement of the air in a room may be determined by burning brown paper and noticing the direction taken by the smoke, or the direction taken by

small particles of light substances, or the effect produced on the flame of a candle. First determine the direction, and then proceed to measure the discharge, which is, of course, equal to the amount entering. The velocity may then be determined by an *anemometer*, by the *manometer*, or by *calculation.*

To find the difference in height of two columns of air. — Multiply the increase of temperature by the constant of expansion, ·002036 for every degree F., and then by the height of the chimney: this will give the difference in height. Thus, $20° \times ·002036 \times 50 = 2·036$. Therefore, 52·036 feet of hot air will balance 50 feet of cold air; or, as air expands $\frac{1}{480}$ of its volume for each degree F., that the temperature is raised from 32° to 212°, we have as in the former case—

$$\frac{480}{212} : \frac{480}{232} :: 50 : X$$

To find the rate of efflux or velocity in a chimney.—Multiply the square root of the difference of the two columns by 8, then multiply by 60, which equals the efflux per minute. As in the case just given, $8\sqrt{2·036} \times 60 =$ velocity per minute. The result should be reduced one-fourth for friction.

$$V = \sqrt{2g \times BC}$$

V = velocity.

g = gravity.

BC = difference in height of the two columns.

Another formula may be used—

$$V = \sqrt{2ga\ (t - T)\ h}$$

V = Velocity. g = acceleration of gravity. a = co-efficient of expansion (·002036). h = height of chimney. t = temperature inside chimney. T = outside temperature.

To calculate the height required to produce a given velocity.—Divide the given velocity by 8, and then multiply the quotient by itself. Thus, $70 \div 8 = 8·75 \times 8·75 = 76·5$ height required.

To find the amount of air discharged at a given velocity by a vane.—The velocity in feet per second, multiplied by the area of the discharge pipe in square feet, will give the number of cubic feet of air discharged per second. Thus, $70 \times 3 = 210$ cubic feet per second $\times 60 =$ per minute.

To find the weight of air passed through an opening at a given velocity.—A cubic foot of air weighs at 60° F. 536·28 grains—that is, about 13·05 cubic feet to the pound ; hence, as in the last case, $\frac{210 \times 60}{13 \cdot 05} = 965 \cdot 40$ lbs weight of air is set in motion per minute with a velocity of 70 feet per second. If it be now asked to calculate the power required to discharge this weight of air at the given velocity, we proceed as follows—

$$\frac{76 \cdot 5 \times 965 \cdot 40}{33{,}000} = 2 \cdot 220 \text{ horse power.}$$

The divisor, 33,000, is the number of pounds weight one horse will raise one foot high per minute: 76·5 is the height from which a body must fall to acquire a velocity of 70 feet per second.

To calculate the expansion of air by heat:—

$$M' = (1 + a\ t)\ M$$

M = volume at 32°, barometer 30 inches.
M' = volume at the temperature of t degrees above 32° F.
a = co-efficient ·002036 for each degree F., or ·003665 for 1° C.

To calculate contraction of air from decrease of temperature:—

$$M' = (1 - a\ t)\ M$$

To find the weight of a cubic foot of air at different temperatures and pressures:—

$$\frac{1 \cdot 3253 \times \text{height of barometer}}{459 + \text{temperature F.}} = \text{lbs.}$$

One pound of coal requires 300 cubic feet of air at 62° F. for its complete combustion, and one pound of dry wood 160 cubic feet.

Given the amount of coal consumed, and the size of the room, the exhausting effect of the fire can be calculated, especially if we consider that a common fireplace extracts 3 to 6 cubic feet per second, and a strong fire 6 to 8 cubic feet.

The velocity of air through public buildings, etc., may be measured by Casella's air meter, a description of which is supplied with each instrument.

Ventilation may be either—

(1) Natural, or (2) Artificial.

1. Natural Ventilation.—Under this division may be classed all those naturally operating causes by

which foul air is removed, and pure air introduced, without the aid of any mechanical means, the efficient causes here at work being *the expansion of air by heat, the diffusion of gases, and the force of the wind.* The air of the room heated by respiration and by contact with the human body, at the same time becoming vitiated by the products of respiration, rises to the upper part of the room, and then escapes by any outlet which it may find. A vacuum occurs, cold air rushes in from any orifice situated near the ground, such, for instance, as the chinks of doors and windows, and thus by natural means ventilation is established. Fires in open grates act in a similar way: a strong upward current is caused by the warm air rushing up the chimney, and cold air from below supplying its place. Modern fire-places only ventilate as high as the opening into the chimney, the air above the mantel-piece remaining for the most part stagnant. Chimneys without fires act as useful ventilators; for the wind blowing over their tops creates a partial vacuum, which is being constantly filled with air from the house. This is due to the aspirating power of the wind. Chimneys may become inlets, due to the following causes:—

1. If there be two fire-places in one room, the one with a fire may cause a down-draught in the other.
2. The fires lighted in the grates in the top rooms of a house may draw air down the chimneys opening into the lower rooms.
3. The flues may be too high for the size of the fire, the heat from which is not sufficient to heat the whole column of air in it. In such a case there is little draught to carry off the smoke, which accordingly enters the room.
4. If a chimney is commanded by higher buildings, the wind blowing over them pours like water over a dam, and passes down the chimney.
5. If, when a fire is lighted in a grate, there is not sufficient air admitted to the room to feed the fire, a down-draught is created. The above are also some of the causes of smoky chimneys.

It is found that, practically, the natural modes of ventilation are not sufficient for the requirements of

thorough ventilation; for in some climates the air may be as hot outside as inside the house, and when this is the case there may be also a dead calm; besides, a greater velocity in the air, and a more rapid interchange, are required in rooms where men or animals are congregated together, than can be obtained by the unassisted powers of nature. "A top window-sash, lowered a little, instead of serving, as many people believe it does, like such an opening into the chimney flue, becomes generally, in obedience to the chimney draught, merely an inlet of cold air, which first falls as a cascade to the floor, and then glides towards the chimney, and gradually passes away by this, leaving the hotter, impure air of the room nearly untouched." A window may, however, be readily used as a ventilator by opening the window and placing a piece of board about six inches deep, and the full width of the window, under the bottom sash, which is then closed down upon it. By this means an air space is left between the two sashes, and the entering air is directed towards the ceiling, and is thus more equally diffused. Another great mistake is also sometimes made in large dormitories—In the morning the custom is to open the windows, and to let them remain open all day long, to be closed only just before bed-time. If there is not sufficient difference of temperature between the outside and the inside, a partial opening of the windows during a winter night is just as necessary as during a summer night. The watery vapour exhaled by the sleepers condenses against the walls, and obstructs the pores. A part is evaporated during the day, but it will be only a part; and hence the not infrequent breaking out of damp spots in such dormitories during the winter.

2. Artificial Ventilation.—Artificial ventilation, on the other hand, includes all those appliances which may be strictly termed mechanical. The punkah used in India is one of the simplest of these appliances, and

consists of a huge fan suspended over a table or bed, and manipulated by pulling a cord by an attendant outside. All the so-called mechanical appliances, however, owe their efficiency to the utilisation of already existing natural agencies. Of these appliances it will be necessary to mention a few of the more important. In some cases it has been proposed to ventilate a room by means of a hollow beam carried from one outer wall to the other. A partition in the middle divides the beam into two equal parts. The wind blowing into one end enters the room by holes made in it, whilst the vitiated air escapes by similar holes in the other end. Rooms may be also ventilated by shafts, etc., opening in the room near to the ceiling; for those in rooms next the roof, a sectional area of one inch to every 50 cubic feet of room space is required; for floors next below, one inch to 55 cubic feet, and for the ground floors, one inch in 60 cubic feet. For inlets, one square inch for every 60 cubic feet of room space (GALTON). All channels for the supply of air should be short, straight, and so placed as to be readily inspected and cleaned. In hot climates it is often necessary to cool the air before allowing it to enter the rooms. This may be done by taking advantage of the law of the cooling of gases by expansion. A steam engine is used to compress the air, and the air so compressed and heated is cooled by passing it over iron tubes through which cold water circulates. In its compressed and cooled condition it is allowed to escape into the rooms, producing by its expansion a further reduction in temperature. Snow-flakes may even be formed by the air as it enters the room.

Sylvester's Method.—This was in use more than fifty years ago, but its application dates from very ancient times. By this plan, the agency of the wind is utilised by the aid of a cowl, which is constantly directed to that quarter from which the wind blows. The cowl

is connected to pipes distributed throughout the house, and through which the fresh air enters the various rooms; another system of pipes is also connected to another cowl turned from the wind, by which the hot vitiated air is removed. Sylvester's method, therefore, combines *perflation*, or blowing in, and *aspiration*, or sucking out. This plan has been largely adopted on sailing-vessels where the ordinary "wind-sail," for carrying the fresh air in, is the only part of the system used, the impure air being allowed to find the best way out for itself. The great drawbacks to this system are—that during periods of calm, the cowls are next to useless, whilst, when the wind is high, the amount of air admitted can neither be regulated to prevent draughts nor a suitable temperature maintained.

Dr Neill Arnott's Method.—Ventilation by means of a hole cut in the chimney as close to the ceiling as possible was suggested in 1849 by Dr Arnott. Several forms of valves for placing in holes near the ceiling have been invented; but a description of their individual merits is not necessary here. The best of these, however, is the Sherringham valve. One objection to Arnott's hole in the chimney is, that sometimes a down-draught forces the soot into the room. He also proposed a modification of Sylvester's plan, with which he ventilated the Field Lane Ragged School.

Dr Chowne's Method. — The use of an inverted syphon. The chimney is used as the long leg, the short beginning near the ceiling. Heat is required to make the air ascend in the long leg. The syphon, in this case, acts differently from its action in water—the air goes up the long leg and down the short one.

Potts' Method.—This consists in placing behind the cornice of a room a tube divided into a lower and an upper compartment. Each compartment is pierced with small holes. The lower is connected by pipes with

the external air, the upper with the chimney or other hot air shaft. The pure air is supposed to enter by the lower and sink gradually to the floor, and the products of respiration escape by the other, which is connected with a chimney or ventilating shaft. Mr Varley's plan is a modification of Potts', in that the pure air is brought in on three sides of the room, and the foul air extracted on the fourth side, connected with the chimney.

M'Kennell's Method.—This consists of two tubes, one encircling the other, the inner tube being always longer than the outer, and protected by a cowl. The tubes are so constructed that the transverse area between them is equal to the sectional area of the smaller. The inner is the outlet tube, and has a flange attached to its lower end, which helps to turn the in-coming air towards the ceiling, and thus enables it to diffuse equally about the room. Both tubes become *inlets*, if there is a fire in the room; if the door and windows are open, both become *outlets.* The tubes should be placed in the centre of the room, and are best adapted to the ventilation of upper rooms or one-storeyed buildings, of square or round rooms, chapels, or churches, the diameters of the tubes being adjusted to meet the requirements of the case.

Stallard's Method.—This is proposed for workshops and factories, and consists in having two ceilings, the lower one of perforated zinc or oiled paper. The space between the two ceilings is open on all sides to the atmosphere.

Tobin's Method—Ventilation by Vertical Pipes.—The origination of this plan is also claimed by Messrs Shillto and Shoreland. The air is brought into the room by tubes placed vertically in the walls, with openings in the room about six feet from the floor. The advantages claimed are that, by admitting air into a room above the heads of the occupants, all draught is

avoided, and a perfect renovation of the air produced, free from the necessity of constant watching. The great failing of this system appears to consist in the smallness of the tubes used, and the difficulty experienced in ensuring the proper action of the inlet tubes, their intended action being liable to be reversed. There is also a good deal of friction in the tubes, and insects and dust may also accumulate in them. The size of the inlet should be about 24 square inches per head, and the same for outlet.

Van Hicke's System.—This is used in some of the hospitals in France and Austria. A large fan forces the air into the basement, where it is warmed and distributed to the wards.

Ventilation by Extraction—known also as the Vacuum Method.—It was by this method Dr Reid ventilated the Houses of Parliament, and consists in connecting the apartment to be ventilated by means of tubes with a ventilating shaft, at the bottom of which a fire is kept burning. An upward current is produced, fed by the air from the tubes. Pure air, carefully warmed, is admitted into the room as fast as the vitiated air is removed. The air in the Houses of Parliament was admitted through minute perforations in the floor. It is on this principle that mines are ventilated by what is known as an *upcast* and a *downcast* shaft, The downcast shaft, through which the air enters the mine, is so connected with the galleries that the air shall first circulate through the mine, and then pass out by the upcast shaft, at the bottom of which a fire is kept burning.

VENTILATION IN COLLIERIES.

$$c = C\left(\frac{480 \times t}{480 \times T}\right)$$

C = length of downcast column. c = length of upcast column. T = number of degrees in excess of 32° F. in C. t = number of degrees in excess of 32° F. in c.

Steamships are ventilated on the same principle as mines, by simply connecting the several parts of the ship with a tube above the furnace fires.

To produce thorough ventilation by a shaft, the shaft must be made as high as possible, for any diminution in its height must be compensated for by increased heat in the shaft, with a consequent increase in the amount of fuel required. The upflowing air should meet with as little friction as possible, and the difference between the internal and external temperature be constantly maintained. General Morin found that, in winter, the ventilation by the shafts in the *Conservatoire des Arts et Métiers* was maintained by the expenditure of 1 lb of fuel for 8700 cubic feet; in summer, only 3000 cubic feet were removed by the same amount of fuel. There are many modifications of this system, but the principle involved is the same.

Several objections have been raised, of which the following alone demand attention :—

1. The inequality of the draught, due to the difficulty of always maintaining the fire at the proper height.
2. The inequality of the movement of the air in the several rooms, those nearest the shafts being more rapidly exhausted than those at greater distances.
3. Regurgitation of smoke from the shaft into the rooms.
4. Difficulty in controlling the supply of fresh air at a proper temperature.

Ventilation by Propulsion—known as the Plenum Method.—This was proposed by Dr Desaguliers in 1734, and consisted in forcing in the air by means of a fan-wheel enclosed in a box. By reversing the action of the wheel, the air could be drawn out of the apartment. St George's Hall, Liverpool, is ventilated by propulsion, the air being first washed, and heated in winter and cooled in summer, is forced through tubes into the building.

As an example of the strictly mechanical means by which ventilation may be effected, the case of the

Senate House in America may be mentioned. In this, a large fan, worked by a steam-engine draws in the fresh air, which, after being warmed by passing over hot pipes, is distributed throughout the house—the amount of air supplied being regulated by calculating the quantity required for each individual present.

Having now given a short outline of the various plans which have been suggested for the ventilation of houses and other buildings, it is well to bear in mind the remarks of Mr Tomlinson, that, "in the rooms of private houses the ventilation must also be spontaneous; for if the slightest trouble be entailed on the inmates, even to the opening of a window, it will be neglected. The means for ventilation must be cheap, easily procurable, always in place, self-acting, not liable to get out of order, requiring no adjustment, no care whatever on the part of the inmates."

Law on the subject of Ventilation.—No provision is made by law for the enforcement of proper ventilation in dwelling-houses, but in the case of factories the following has been enacted:—

"FACTORY ACTS EXTENSION ACT, 1867" (27 & 28 Vict., c. 48).

This Act also applies to Scotland.

VENTILATION OF FACTORIES.

Sec. 4.—Every factory to which this Act applies shall be kept in a cleanly state, and ventilated in such a manner as to render harmless, so far as is practicable, any gases, dust, or other impurities, generated in the process of manufacture, that may be injurious to health.

Penalty for neglecting this rule, not exceeding ten pounds, nor less than three pounds.

By another Factory Act--1867 (30 & 31 Vict., c. 183)—greater provision is made for every factory where grinding, glazing, or polishing on a wheel, or any other process carried on by which dust is generated and inhaled by the workmen to an injurious extent, etc. Occupier must provide fan, or other mechanical means, to remove nuisance. Penalty as above.

WARMING.

The Laws of Heat.—Before discussing the methods of warming our houses, etc., it is necessary briefly to consider the laws of heat. According to the nature of the surrounding media, heat is propagated in one or more of three different modes, known as *radiation*, *conduction*, and *convection*. Radiation is alone possible in a perfect vacuum, and conduction within a solid body; but when the medium is gaseous all three may co-exist. In the case of liquids, conduction and convection occur together. Radiant heat is given out in all directions from the radiating body, undulations being produced in the ether. This is also the case with light, and is governed by the same laws. Radiation takes place in vacuo, as in air, without warming the intervening space. Radiant heat is propagated with equal intensity in all directions and in right lines, and may be intercepted by a screen. Like light, it is subject to the laws of refraction. The intensity of radiant heat depends upon its source, and on the distance it travels; and like light is directly proportional to the temperature of the source, and inversely as the square of the distance. As also in the case of light, radiant heat is reflected on falling on a solid body, the angles of incidence and reflection following the same laws of equality, and real foci from concave surfaces are formed, though the virtual foci of optics have no analogues here. A portion of the radiant heat is absorbed and a portion reflected; but the absorbing power of a body is always inversely as its reflecting power, and depends on the material, surface, and colour of the body. Radiation and absorption are equal, and governed by the same conditions. As in the case of light, we speak of transparent and opaque bodies; so with heat, we have diathermanous and athermanous bodies. To radiant heat, clear glass is diathermous; but it is athermous to obscure rays

of heat. A glass-house is thus a "trap to catch a sunbeam," the glass allowing the radiant heat from the sun to pass through, but obstructing the obscure rays radiated from the walls, etc. Hence, a glass screen before a fire will obstruct the obscure rays of heat radiated from the fire; but will allow the radiant heat to pass; and this is especially the case if the heating body be a stove. The action of the "cosey" may be thus explained. If the surface of the teapot be black or dark, heat is rapidly radiated, its loss being prevented by the cosey, which, being usually made of bad conducting material, radiates the heat back to the teapot. In the case of a bright silver teapot, some heat would still be radiated, which is also arrested by the cosey. Under the same conditions, the tea would retain a higher temperature in the bright than in the dark pot in a given time. The aqueous vapour in the atmosphere absorbs a large amount of dark heat, but allows the light rays to pass with little diminution: the earth is thus warmed, but radiation of heat into space is prevented by the aqueous envelope. Glass, water, alum, and most transparent bodies, do not allow the dark heat rays to pass; but to this rule rock salt is an exception.

Specific Heat. — Under given conditions we may define specific heat as the quantity of heat required to raise the temperature of one pound of the substance by 1° C. The specific heat of a substance, as a rule, increases with rise of temperature; but platinum is an exception, as its specific heat varies very slightly with temperature, and it may thus be used for the measurement of high temperatures.

Thermal Capacity.—This is equal to the product of the specific heat and the density of the substance, and is the quantity of heat which is requisite to raise the temperature of unit volume of the substance by one degree.

Determination of Specific Heat.—Three methods are employed:—(1) The method of melting ice. (2) The method of mixtures. (3) The method of cooling.

The first method is performed by heating the substance to a certain temperature, and then placing it in a cavity formed in a block of ice provided with a cover of ice. When the body becomes cooled to zero, it is removed, wiped with a dry weighed sponge; which is also used to remove all the water in the cavity, and the sponge again weighed. Increase of weight equals weight of ice converted into water. To melt one pound of ice 80 thermal units are required. We have, therefore,

$$C = \frac{80\ P}{m\ \ t}$$

The second method may be adopted for solids or liquids, the following formula being used—

$$c = \frac{m\,(\theta - t)}{M\,(T - \theta)}$$

c = specific heat required. M = weight of body whose specific heat is required. m = weight of water. T = temperature of body. t = temperature of water. θ = resulting temperature.

Example— $$c = \frac{m\ 20\ (22\ \theta - 20\ t)}{M\ 4\ (130\ T - 22\ \theta)} = \cdot 0095$$

The third method is performed by noting the time required by a substance in cooling from a given temperature. This method is not satisfactory for solids, but may be used with success for liquids.

Thermometric Scales.—There are three thermometric scales in use, those of Fahrenheit, Réaumur, and Celsius, or the Centigrade. The Fahrenheit scale was invented by Fahrenheit in 1714, the higher point being that of boiling-water; the lower, the temperature of a mixture of equal weights of ammonium chloride, and snow. The interval between the two points is divided into 180 degrees. The zero of Fahrenheit is 32 of its own degrees below freezing point In Réaumur's scale the

interval between the lower and higher point is divided into 80 degrees; in Celsius, into 100 degrees. To convert the three scales into one another, we have—

$$F = \frac{9\,C}{5} + 32 \qquad C = \frac{5\,(F-32)}{9} \qquad F = \frac{9\,R}{4} + 32$$

$$R = \frac{4\,(F-32)}{9} \qquad 5\,R = 4\,C$$

In England the warming of dwellings is effected at great waste and cost by open fire-places—the English prejudice against stoves being apparently unconquerable. Of late several ventilating and warming fire-places and stoves have been introduced. Among these may be mentioned the Calorigen stove invented by Mr George, Pierce's Pyro-pneumatic stove grate, and the Goldsworthy Gurney stove. The Galton stove consists in having the grate so placed that an air chamber is formed behind it, communicating freely with the external air and the air of the room. The warmed air enters the room near the ceiling, and the openings are so regulated that the air, passing over the hot back of the stove, is not injured. Radiant heat does not sensibly warm the air through which it passes, but bodies which intercept the rays of heat become warm, and impart their heat to the air around them. This is true of high temperatures, but with more moderate temperatures the heat is nearly equally divided between the walls and the air. If we wish, therefore, to warm the walls of a room, and thus remove their moisture, stove pipes at a high temperature must be used. The reason that a person feels cold in a room in which a fire has just been lighted, is due to the fact that the heat from his body and that from the fire is radiated to the colder furniture and walls of the room. When these are warmed, the heat from them warms the air, and he then feels comfortable.

In the United States and Canada, heating by hot water, steam, or hot air is largely adopted. Heating

by hot water is of the three the one to be preferred, but it is slow to put in action, leaks may occur, and it is somewhat costly. Steam heating requires care, as explosions are not rare, and considerable noise is made by the steam entering the pipes in the morning after the apparatus has grown cool. Hot air heating is the cheapest, but the air is too dry, and may be burnt if care be not taken in adapting the inflow of air to the size of the furnace. In this form of heating a furnace is placed in the cellar, cold air from the outside of the house plays over the furnace, and is then conducted by bright tin pipes, to prevent radiation, to the different rooms, into which it is admitted by gratings.

Open fire-places and closed stoves differ in several important material points. An open fire warms the air by first warming the walls of the room and articles of furniture, which in their turn impart their heat by radiation to the air in contact with them. Close stoves, heated to a moderate temperature, warm the air in contact with the outer surfaces; but, if heated to high temperatures, radiant heat is emitted and the walls and furniture are first warmed, acting therefore like open fire-places. Hot-water pipes act as closed stoves. There are several objections to the use of iron stoves: they rapidly become red-hot, and as rapidly cool down; when red-hot they generate CO, either from the materials of combustion, or by converting the CO_2 in the air of the room into CO.

In Canada, it is no uncommon thing to see an iron stove and a foot or two of the stove pipe red-hot in a small room crowded with people. Brick or terra cotta stoves, although worse conductors of heat, are not open to the objections of the iron stove, whilst they have the advantages of cooling slowly and imparting a more equable temperature to the air of the room.

Mr Teale has laid down the following rules with regard to open fire-places—

1. The use in their construction of as much fire-brick as possible.
2. The back and sides should be of fire-brick.
3. The back should lean or arch over the fire.
4. Deep from before backwards;—for a small room, at least 9 inches.
5. The slits in the grating should be narrow.
6. The front bars should be narrow.
7. The space under the grate should be closed in by a shield or "economiser," or a plate of iron put at the bottom of the fire-place within the grate.

Hospital wards should be heated by open fires, the radiant heat from which warms the walls and prevents the abstraction of heat by the walls from the bodies of the patients, which occurs when closed stoves are used. The passage of heat through different materials—*e.g.*, Craigleith sandstone—depends upon the conductivity of the material, its thickness, and the difference between the temperature on the inner heated surface and the outer or cooled surface.

The following formula may be used—

$$Q = \frac{k\,(V - v)\,t\,a}{d}$$

Q = the quantity of heat. V = temperature of hotter side. v = temperature of cooler side t = the time. a = the area. d = thickness of material. k = constant.

Example.—How much heat will escape in an hour from the walls of a building, if their area be 80 square metres; their thickness, 20 c.m.; their material, sandstone of conductivity ·01; and the difference of temperature between the outside and inside, 15 degrees

$$Q = \frac{\cdot 01 \times 60 \times 60 \times 8000 \times 15}{20} = 21600000 \text{ g.m.-deg.}$$

To find the quantity of 4-inch pipe required to warm a given space:—

1. Multiply the excess of the temperature of the pipe above that of the surrounding air by the difference between the temperature at which the room is purposed to be kept when at its maximum and the temperature of the external air.

2. Divide the product by the difference between the temperature of the pipes and the proposed temperature of the room.

3. The quotient thus obtained must be multiplied by the number of cubic feet of air to be warmed per minute.

4. Divide this product by 222*: the result is the number of feet of 4-inch pipe required.

* 222 = the number of cubic feet of air raised one degree per minute by one foot of 4-inch pipe.

$$L = \frac{(P-t) \quad (T-t)}{P-T} \times \cdot 0045\, C$$

P = temperature of pipes.
T = " required in building.
t = " external air.
C = cubic feet of air to be warmed per minute.
L = length of pipe in feet.

·0045 C for 4-inch pipes.
·006 C " 3-inch "
·009 C " 2-inch "

The length of 3 or 2-inch pipe required may also be found by multiplying the length of 4-inch pipe, given by the above rule, by 1·33 and 2 respectively.

To find the length of 4-inch pipe to warm a Church.—Divide the cubic contents of the church by 200, the result will be the length of pipe required.

The length of pipe required for Dwelling Rooms.—Twelve feet of 4-inch pipe for every 1000 cubic feet at 65° F.

The length of pipe required for Work Rooms.—Temperature, 50° to 58° F., six feet of 4-inch pipe per 1000 cubic feet.

The length of pipe required for School and Lecture Rooms.—55° to 58° F., six feet of 7-inch pipe per 1000 cubic feet.

Every square foot of glass will cool 1·279 cubic feet of air as many degrees per minute as the internal temperature of the room exceeds the temperature of the external air.

The following data will be found of use—

1 lb of H requires for combustion 8 lbs of O, equivalent to 36 lbs, or about 470 cubic feet of air. 1 lb of C requires 2·69 of O, equivalent to 12 lbs, or about 157 cubic feet of air at 62° F.

From the above, the net weight of air chemically required for complete combustion of a unit weight of fuel, may be found by the following formula—

$$12\,C + 36\left(H - \frac{O}{8}\right)$$

METEOROLOGY.

CLIMATE.

Climate (κλίμα—slope, inclination) may be said to embrace all those physical influences connected with the soil, heat of the atmosphere, or the water of a place, which, acting and reacting upon man, more or less materially affect him.

In considering the effects of climate on the inhabitants of a place, the following must be taken into consideration:—(1) The Density of the Population. (2) The Ages of the Living. (3) Occupation. (4) Differences of Food. — Climate should also be considered separately in reference to the indigenous inhabitants and to strangers.

The severity of the climate on the coasts and in islands is diminished by the absorption during the summer by the sea of the sun's rays, which penetrate deeper into it than into the land. The sea, owing to its saltness, does not freeze so soon as fresh water; and imparting its heat to the winds that blow over its surface, affects the temperature of countries situated on its margins. The luxuriant vegetation of the countries bathed by the large expanse of ocean in the Southern hemisphere, is strikingly contrasted with the barrenness of the land in the Northern, where, from excess of land, the air is rendered cold and dry.

Climate is divided into Continental, Insular or Sea, and Mixed Climate.

A *Continental* Climate consists in a cold winter and a hot summer.

An *Insular* Climate is characterised by a cool summer and mild winter.

A *Mixed* Climate is inclined to be *Continental* in winter and *Insular* in summer.

Asia is an example of the first, Europe of the second, and North America of the third.

Climate cannot be determined exclusively by mean temperature, as places often differ materially in climate, although having the same mean annual temperature. This arises from the circumstance that an extreme degree of heat in summer and cold in winter in one place, may give a mean annual temperature not materially differing from another place having a more equable temperature throughout the year.

The climate of a place depends upon a variety of circumstances, which we may tabulate as follows:—

1. Purity and Hygrometric State of the Atmosphere.
2. Influence of Trees and Forests, and Sandy Deserts.
3. Influence of Lakes, Marshes, and Rivers.
4. Influence of the Sea.
5. Influence of Hills and Mountains.
6. Influence of Efficient Drainage and Sewerage.

1. Purity and Hygrometric State of Atmosphere.

The normal constitution of the atmosphere consists of a mixture of oxygen, nitrogen, and aqueous vapour, with traces of carbonic acid. The amount of aqueous vapour depends upon the temperature and pressure of the atmosphere, but the proportions of the gases present are nearly the same everywhere.

Humidity.—This term is held to imply the amount of vapour present in the air, and also the ratio of this to the amount which would saturate the air at the actual temperature. The amount of vapour in the air is not a measure of its humidity, for the air is for the most part drier in summer than in winter, although the amount of vapour present is much greater. The vapour also like the temperature, decreases as we ascend but the rate of diminution of vapour is more rapid than that of the temperature. The vapour in the air acts in two ways: it moderates the heat of the sun, and also prevents the

radiation of heat from the earth into space. According to Tyndall, a sheet of vapour, being in a great measure impervious to heat, acts as a screen to the earth.

Relative Humidity. — The percentage of moisture in the atmosphere, complete saturation being taken as 100.

Absolute Humidity.—The actual amount of moisture in a given quantity of air.

Tension of Aqueous Vapour.—Expressed in inches of mercury, being the elastic force of vapour in the atmosphere.

Instruments used for finding the Humidity of the Air :—

(1) Hygrometers of Absorption, or Hygroscopes.
(2) Condensing Hygrometers, or Dew Point Instruments.
(3) Psychrometers, Hygrometers of Evaporation, or Wet and Dry Bulb Thermometers.

Another division of these instruments is into *direct* or *indirect* hygrometers, thus—

DIRECT.—Leroy, Daniel, Regnault, and Dines' hygrometers.

INDIRECT.—Saussure's hygroscope; the dry-and-wet-bulb hygrometer.

(1) Hygrometers of Absorption, or Hygroscopes.

These instruments depend upon the fact that all organic substances are affected by moisture, which generally increases their dimensions. The hair hygrometer, or rather *Hygroscope*, of Saussure is a very imperfect instrument, as much depends on the previous preparation of the hair, and the length of time it has been in use. This instrument consists in an oblong frame, to the top of which one end of a hair is attached, the other end being fixed to an axle carrying an index. By the shortening or lengthening of the hair acting on the axle, the index is made to move along a graduated arc.

(2) Condensing Hygrometers, or Dew Point Instruments.

Leroy's Hygrometer.—The simplest instrument of the kind consists of a bright tin vessel filled with water artificially cooled, and having a thermometer immersed in the water. A deposit of moisture forms on the sides of the vessel when the temperature of the water falls below the due point of the surrounding air. The deposition of dew does not, however, begin till the point of saturation has been passed: the indication of the thermometer is, therefore, slightly too low. Besides this objection, there is another of more importance: the placing of a vessel of water open to the air in the very place where the humidity of the air is required to be determined.

Daniel's Hygrometer.—A straight glass tube, supported on a stand, with a bulb at each end, at right angles to the straight part. One of the bulbs contains pure ether, over which a thermometer is suspended; the other bulb contains the vapour of the ether, and is covered by a piece of thin muslin. To use the instrument, the muslin is wetted with ether; this causes a condensation of the ether vapour, giving rise to an increase of evaporation of ether from the naked bulb, producing a commensurate decrease of temperature. The temperature at the moment of the deposit of moisture on the ether bulb is noticed, and is found to be a little lower than the dew point. If, however, the instrument be then left alone, and the temperature noted at the moment of the disappearance of the dew, the mean of the two readings will give the correct dew point. A thermometer is generally attached to the stand, and gives the temperature of the adjacent air. On account of the boiling point of ether being 36° C. (97° F.), this hygrometer cannot be used in very hot climates.

Regnault's Hygrometer.—A modification of the foregoing, but more accurate in its results. It consists of two thin glass tubes, A and B, corked at one end, and fitted into two thin silver thimbles, suspended on a stand. A thermometer is placed in each, the stems of which pass through the corks. The tube A contains some ether, and a glass tube opening below the ether passes through the cork, and is open to the air. The tube A is connected with an aspirator. The instrument is thus used: the cock of the aspirator is turned on, air is drawn through A, and the temperature noted the moment the silver thimble becomes tarnished with moisture. The thermometer in B gives the temperature of the air, that in A the temperature of the dew point.

Dines' Hygrometer.—A glass vessel connected with a pipe at the bottom, which is placed close under a plate of black glass. A thermometer is so arranged that, when a stop-cock is opened, the cold ice water flowing from the vessel may cool the glass, and also surround the bulb of the thermometer. The glass plate soon becomes dulled, and the thermometer is read. The water is now turned off, and as soon as the glass becomes bright the thermometer is again read. The appearance and disappearance of the dullness marks the due point. This instrument is very useful in determining the amount of moisture in a room.

(3) Psychrometers, Hygrometers of Evaporation, etc.

This instrument, the dry and wet bulb hygrometer, consists of two identical thermometers placed at a short distance from each other on a stand, the bulb of one being free, whilst the bulb of the other is covered with a piece of muslin, kept moistened with water by means of a cotton wick leading from a vessel containing water. The depression in the muslin covered thermometer only measures the *evaporating* power of the air, but

as this depends on the amount of moisture present in the air, the wet bulb thermometer indirectly measures the humidity of the air. The greatest objection to the use of this instrument is that during frost it is impossible to get reliable indications from it. It is, however, useful in hospital wards for determining the amount of moisture present in the air.

Precautions to be observed in using this instrument :—

1. Free circulation of air round the wet bulb must be maintained.
2. The vessel containing the water should be small, and placed some inches from both bulbs.
3. The muslin must be kept thoroughly moist, but not allowing a collection of water at the bottom of the bulb.
4. When the wick is frozen in winter, the bulb must be dipped in water, and time allowed for the water on the bulb to freeze before an observation is made.
5. Both thermometers must be exactly alike. To use this instrument, take the difference between the dry and wet bulb, and multiply it by the factor given in Glaisher's Tables standing opposite the *dry* bulb temperature: deduct the product from the *dry* bulb temperature : the result is the dew point.

The following incomplete Table will show how the above is calculated out :—

GLAISHER'S FACTORS.

Dry Bulb Therm.	Factor.	Dry Bulb Therm.	Factor.	Dry Bulb Therm.	Factor.
10	8·78	21	7·88	32	3·32
11	8·78	22	7·60	33	3·01
12	8·78	23	7·28	34	2·77
13	8·77	24	6·92	35	2·60
14	8·76	25	6·53	36	2·50
15	8·75	26	6·08	37	2·42
16	8·70	27	5·61	38	2·36
17	8·62	28	5·12	39	2·32
18	8·50	29	4·63	40	2·29
19	8·34	30	4·15	41	2·21
20	8·14	31	3·70	42	2·23

Example— Dry Bulb = 40°.
Wet Bulb = 36°.
40° - 36° = 4° × 2·29° = 9·16°.
40° - 9·16° = 30·84°.

Apjohn's formula for calculating the tension of aqueous vapour at the dew point temperature :—

$$F = f - \frac{d}{88} \times \frac{h}{30} \quad \text{or} \quad F = f - \frac{d}{96} \times \frac{h}{30}$$

d = the difference of wet and dry bulb thermometers in Fahrenheit degrees.
h = barometric height in *inches*.
f = the tension of vapour for the temperature of the *wet bulb*.
F = elastic force of vapour at dew point.

The constant 88 is used when the reading of the wet bulb is above 32° F., and 96 when it is below.

Dew.—Dr Wells first gave a correct explanation as to the cause of dew. He showed that when, as the result of radiation, objects near the earth's surface became cooled down to a certain point, a deposit of moisture formed on them. This is *dew*, and it plays an important *rôle* in the economy of nature besides merely supplying water to plants, in which it performs the functions of rain. The deposition of dew produces enough heat to protect plants from a considerable degree of cold. In fact, a single gramme of water vapour condensed on a plant furnishes sufficient heat to raise 500 grammes of water one degree, and to raise the temperature of the plant itself eight degrees, if we suppose the plant to weigh 75 grammes (E. Bouant). No wonder then that the poets have called flowers "the daughters of the sun and of the dew." "It is dew," says M. Jamin, "that protects the earth from the visitations of frost; it is by this beneficient phenomenon that plants are protected from freezing, by returning to the air the vapour which they have in reserve and the heat which they have caught; then when the sun appears in the morning, his first duty will be to convert the dew into vapour and store up afresh the heat which has been dissipated."

CIRCUMSTANCES FAVOURABLE TO FORMATION OF DEW.

1. *A cloudless night and free exposure to the sky.*—Clouds, by reflecting back the heat radiated from the earth, prevent the deposition of dew.

2. *A nearly tranquil atmosphere.*—Wind, by producing an interchange of air of varying temperatures, prevents sufficient depression of temperature, and therefore arrests the formation of dew.

3. *An atmosphere charged with moisture.*

4. *Good radiators and bad conductors.*

Good radiators and bad conductors—Wool, hare-skin, glass, etc. Dew freely formed.

Good conductors and bad radiators—Metals, etc.—Dew formed with difficulty.

Dew is not formed on the surface of large bodies of deep water, for the cold particles of water sink, to be replaced by warmer particles from below, thus preventing a sufficient depression of temperature to allow of the deposit of dew. It is also not formed in the midst of sandy deserts, the atmosphere being too dry.

The *dew point* is the lowest temperature to which the air can be cooled down (at constant pressure) without depositing some of its vapour in the form of liquid water, or "the dew point is the temperature at which saturated water vapour would have the same pressure as that of vapour present in the air at the time," and can be calculated directly from Regnault's Tables if we know the quantity of vapour per cubic foot of air. Let it be supposed that the walls, ceiling, and floor of a room have been saturated with water, what will be the dew point? Here of course the water vapour present is saturated vapour, and therefore, what the dew point is will depend entirely on the temperature of the room; but dew will begin to be deposited as soon as the temperature falls below that which, as ascertained by Regnault, corresponds to the pressure of the water vapour present—*e.g.*, if the temperature of the room be 40° C., then the vapour pressure corresponding to this is 54·906 m. m. of mercury; and if the vapour pressure in the room be greater than this, then the excess will be deposited as dew; or conversely, if the vapour pressure present be 54·906, then the dew point is 40° C.; because if cooled the least bit below this, dew is deposited.

An early determination of the dew point may often be the means of foretelling a coming frost, and thus permit means to be taken to prevent the destruction of tender plants. Other things being favourable, a dew point at or about 29° indicates frost. To protect the wheat crops in Manitoba from early frost it has been proposed to form clouds of smoke by setting fire to damp straw, the smoke so produced acting as a shield, preventing radiation.

Hail.—Hail consists of masses of hardened snow with a coating of ice. The hailstones vary in size and form.

Hoar-Frost.—A lower temperature is required for the formation of hoar-frost than for dew, which, however, is not frozen dew, but the moisture of the air deposited in a solid form. The crystals of hoar-frost are hexagonal prisms, with angles of 120°.

Formation of Clouds.—Clouds are formed by the condensation of vapour in a stratum of air at a low temperature, and at a considerable height—one to four miles—above the surface of the earth.

There are three varieties of clouds usually recognised by meteorologists as follow :—

1. CIRRUS, or the *Mare's Tail* of sailors, occupies the highest region of the atmosphere. It is higher than any point yet reached by balloons, and is probably composed of small particles of ice.

2. CUMULUS consists of rounded masses resting on straight bands, and having the appearance of hills or mountains. Sometimes they present the form of *balls of cotton* or *wool packs*, by which names they are known to sailors. They are most common in summer and during the day.

3. STRATUS consists of horizontal sheets, which form at sunset and disappear at sunrise. The strati are the lowest clouds. Besides these, which are the primary forms, there are several combinations of the above described — viz., *cirro-stratus*, *cumulo-stratus*, *cirro-cumulus*, and the *cumulo-cirro-stratus*.

The cirro-cumulus forms the well-known *mackerel sky*.

The cumulo-cirro-stratus, also known as the *rain-cloud*.

The cirrus, cirro-cumulus, and cirro-stratus are the higher; the stratus-cumulus, and cumulo-stratus, the lower clouds.

(The above classification of clouds is that of Howard)

Any cloud discharging rain has had the term *nimbus* applied to it.

Suspension of Clouds.— Clouds appear to be suspended in the air, because they are being continually formed. The heated air rises, is condensed, forms a cloud, and begins to fall; but, coming in contact with warm air rising from the surface of the earth, is vapourised, again ascends, and is again condensed, to form a cloud. Clouds are constantly disappearing to be re-formed. From this we may explain the curious phenomenon of a cloud clinging to a high mountain, even with a strong wind blowing. The fact is, the cloud is as quickly formed as blown away.

The Estimation of Cloudiness.—The figures usually adopted are from 1 to 10. 1, Perfect freedom from cloud; 10, the maximum of cloud; any intermediate stage is marked 3, 4, 5, etc., as the case may require.

A *Mist* is a cloud near the ground.

A *Fog* is a cloud resting on the earth, and occurs when the surface of the ground is warmer than the air in contact with it. The hot air rises to be condensed into fog. The fogs off Newfoundland are due to the excess of heat of the Gulf Stream above the cold moist air on its surface and over the banks. A fog may also be caused when hot moist air flows over a river with a temperature lower than the air; for then, the air being cooled as soon as it is saturated, the excess of vapour present is condensed. The London fogs are due to the artificially heated smoky air over the city, and the close proximity of the river Thames. It appears that these fogs are the result of a deposit of moisture on the particles of carbon or other matter in minute division suspended in the atmosphere. As Aitken has shown that condensation cannot commence in free air unless dust-nuclei are present. Fogs seldom occur over deserts, and are not common in tropical countries, except round the tops of high mountains.

Rain.—As the clouds consist of particles of water, they are constantly raining; but between the clouds and the earth there is usually a non-saturated belt or region where these particles of water, when small, are evaporated before they reach the earth. When this belt becomes saturated, the particles coalesce, and rain is the result. We have already seen that when the moisture in the air is condensed as dew, that a considerable amount of heat is set free. The same occurs, but to a greater extent, during a fall of rain.

The Rev. Dr. Haughton has calculated that "one gallon of rainfall gives out latent heat sufficient to melt 75 lbs of ice, or to melt 45 lbs of cast iron." "From this datum," he continues, "it is easy to see that every inch of rainfall is capable of melting a layer of ice upwards of eight inches in thickness (exactly 8·1698 inches) spread over the ground."

If this be so, the heat derived from the rainfall on the west coast of Ireland is equivalent to half that derived from the sun. The condensation of one grain of aqueous vapour gives out enough heat to raise 536 grains of water 1° C. The unit of heat is 5760 grains of water raised through 1° C. One grain of vapour, when condensed, sets free $\frac{536}{5760} = 0·093$ units of heat.

The specific heat of air is 0·2375, and a cubic foot of air weighs 560 grains; so that the condensation of one grain of aqueous vapour raises the temperature of one cubic foot of air $\frac{5760 \times \cdot 093 \times 9}{560 \times \cdot 2375 \times 5} = 7·25°$ F.

For one-tenth of an inch of rain it has been calculated that there is a rise of temperature in the lowest mile of the atmosphere equal to 3·3° C., sufficient to cause a considerable upward current. By the almost constant rains in the equatorial regions, an enormous amount of latent heat is set free, and the air thus rarefied helps to produce the trade winds. To this rarefaction we may

trace the cause of the low barometer in the same regions. In higher latitudes, due to precipitation also, we find a low barometer and variable winds.

CAUSES THAT INFLUENCE THE RAINFALL.

1. *Latitude.*—The greatest rainfall is near the equator, diminishing towards the poles. But the number of rainy days at the equator and at latitude 60° are very nearly the same.
2. *Elevation above the Sea.*—Mountains increase the rainfall.
3. *Proximity to the Ocean.*—It is almost always raining on the west coast of Ireland and Britain. The Gulf Stream has much to do with this rainfall.
4. *Trees.*
5. *Winds.*
6. *Deserts.*—Almost entire absence of rain.

Rain may occur without clouds, due to clouds not in the zenith. It has also been suggested "that when rain falls from a cloudless sky, the vapour is condensed in a few large drops instead of a multitude of minute ones."

A *rainy day*, $\frac{1}{100}$ of an inch (SYMONS).

Mode of Estimating the Rainfall.—There are several forms of rain gauges. The simplest consists of a funnel opening into a receiver in which the rain is collected, and from which it may be drawn and measured. The funnel should have a truly horizontal rim, else the gauge will catch too much or too little, according to the direction and force of the wind.

Some observers maintain that the rain gauge should be placed *at least six inches* from the ground, to avoid splashing, and in the centre of a level, open plot; others that the best location for it is to bury it in the earth, making its top just even with the surface of the ground (LOOMIS). For some unexplained cause, the higher the gauge is placed above the surface of the earth the less rain it catches. The best time for measuring the rainfall is 9 A.M.

To calculate the quantity of rain intercepted by rain gauge.—Multiply the area of gauge by 252·458, divide product by 437·5; the result is the weight in ounces of one inch depth of rain over area of gauge.

252·458 = weight in grains of 1 cubic inch of water at 62° F.
437·5 = " " of 1 ounce avoirdupois.

$$w = \frac{a \times 252{\cdot}458}{437{\cdot}5}$$

w = water in ounces. a = area of gauge, $D^2 \times 0{\cdot}7854$.

Suppose the diameters of the rain gauge and collecting glass be given, to find the depth of the glass to contain one inch of water collected by the gauge. The diameter of gauge = 7 inches, glass, 3 inches.

$$7^2 \times 0{\cdot}7854 = 38{\cdot}4846 \text{ area of gauge.}$$

$$\frac{38{\cdot}4846 \times 252{\cdot}458}{437{\cdot}5} = 22{\cdot}205 \text{ oz. of water.}$$

Then

$$\frac{22{\cdot}205}{3^2 \times 0{\cdot}45317} = 5{\cdot}44 \text{ depth of glass required.}$$

0·45317 = a constant which may also be used to find the weight of an inch of water intercepted by the gauge, by multiplying the square of the diameter by it.

According to Mr Symons, the mean annual rainfall is—at London and Edinburgh, 24 inches; Liverpool and Manchester, 35 to 36; Dublin, 30; Glasgow, 40; Dartmoor, 86; and on Ben Lomond, 91.

ATMOSPHERIC ELECTRICAL PHENOMENA.

The atmosphere is always more or less charged with positive electricity, especially during fine weather. During stormy, or broken weather, negative electricity is as frequently met with as positive, and it is at such times that the indications of the presence of electricity are most marked. It is also during this state of the weather that the electric phenomena, partaking of the nature of the "brush discharges" of the electrical machine, and known as St Elmo's Fire, occur. "Comozants," a name also given to this phenomenon, is a corruption of

"corposants"—*corpus sanctum.* The phenomenon is often seen during a storm, when the tops of the masts of ships appear tipped with flames. Plutarch mentions that a like appearance occurred as the fleet of Lysander left Lampsacus, and was then attributed to the presence of Castor and Pollux. Cæsar also relates that during a stormy night the spears of his fifth legion were tipped with fire.

SOURCES OF ELECTRICITY.

1. Vegetation.
2. Evaporation from salt or saline water.
3. Condensation of vapour during storms.
4. Unequal distribution of heat.
5. Atmospheric friction.
6. Combustion at earth's surface.
7. Friction of the water vapour particles against the air particles, because when two different bodies are in contact they always give off electricity.

If moisture be in the form of true vapour, electricity is not generated.

DIURNAL AND ANNUAL RANGES.

1. The electricity of the air, estimated always at 'he same height, undergoes a diurnal variation, which generally presents two maxima and two minima.
2. The maxima and the minima vary according to the seasons of the year.
3. The first maximum occurs in summer before 8 A.M., and in winter towards 10 A.M.; the second maximum occurs in summer after 9 P.M., and in winter towards 6 P.M. The evening maximum is the greatest.
4. The minima of the day are towards 4 A.M. and 4 P.M.
5. The mean is probably about 11 A.M.

Of the *Annual range*, the winter is greater than the summer; the greatest intensity is in January, and the least in June.

Forms of Lightning. — Zig-zag, sometimes forked, ball, sheet, and heat lightning. Sheet lightning is due to the lightening up of the clouds by forked lightning behind the cloud.

Duration of Lightning.—About the one-millionth part of a second. If the flash lasted the thousandth part of a second, objects would be as brilliantly illuminated by it as they are in the sunlight. Ball lightning is somewhat longer.

Causes of Thunder.—The in-rush of air into a vacuum produced by the lightning. A sudden expansion of air on all sides of the lightning flash, followed by an almost instantaneous in-rush of air when the flash has passed, is the cause of thunder; which thus occurs at the same time as the flash, but owing to the greater velocity of light, is not heard at the moment of the flash. This distance of the flash from the observer may be determined by allowing five seconds per mile between the flash and the thunder. The duration of a thunderclap varies from 20 to about 56 seconds, and is never heard more than fifteen miles off from the flash of lightning.

Lightning Conductors or Rods.—Electricity travels along the best conductors, which are the metals. Lightning rods are, therefore, made of iron, pointed with copper or platinum, carefully insulated, and having one end buried in the ground. Care must be taken that the connection with the ground be continuous, that the diameter of the rod be about $\frac{9}{10}$ of an inch, and that in no part of its course must it come near any of the metal pipes connected with the house. In the ground it may be connected with the iron gas and water pipes, or be attached to branching rods buried in the ground and surrounded with coke. Lightning conductors probably act in two ways: by affording a means by which the electricity may travel to the ground, and also by lessening the severity of the shock by allowing, by their pointed extremities, the gradual exchange of the opposite electricities of the clouds and earth. A sharp point connected with the earth modifies the sparks from the conductor of a machine.

Return Shock.—Bodies within the influence of a cloud charged with electricity become charged with the opposite to that of the cloud. As soon as the cloud has discharged its electricity into the earth, the return of the electrified bodies to the neutral state causes the *return shock.*

Aurora Borealis.—This is a diffuse light like the morning twilight, sometimes, however, assuming certain curtain-like forms, seen at both the terrestrial poles; hence, the proper designation of these phenomena should be *polar lights.* The aurora assumes an arched form of considerable extent, and varying in colour from a pale straw to a rosy tint, depending upon the amount of condensed vapour in the atmosphere and the height above the earth. The dark portion of sky under the arch is known as the "dark segment" of the aurora, and is due to the condensation of the vapour of the air, probably existing as spiculæ of ice or flakes of snow. The cause of the phenomenon is little understood, but it is evidently electrical, as shown by the effects produced on the telegraph wires and magnetic needle during the auroral display of 1859. The beams of light are often in constant motion, keeping up a perpetual dancing motion; hence in high latitudes they are known as the *merry dancers.* I have frequently, in Manitoba, seen this dancing action. Some observers have stated that a peculiar crackling sound accompanies auroral displays; others have denied the existence of these sounds. The height of auroras has been variously estimated from 100 to 2000 feet. Auroras are not seen in the tropics, because in these regions the electricity has greater intensity, and moves with explosive violence in thunder-storms.

Electrical Condition of the Air—How Determined? —An arrow may be shot into the air connected to an electroscope by a fine wire. It is found that as the arrow ascends the gold leaves of the electrometers

diverge along an ivory scale, graduated to twentieths of an inch. Two straws may be used in the place of the gold leaves. An insulated thin copper tube, sixteen feet high, tipped with platinum points, is used at Kew. The tube passes through the dome at the top of the observatory, and is supported on a glass cylinder. It may be connected at pleasure with the electrometers. Captive balloons, attached to conducting wires connecting them with electrometers, are sometimes used to estimate the intensity of the electricity at varying heights.

Thermo-electric Pile.—This instrument is based on the principle that when two or more metals, all at the same temperature, are joined together so as to form a closed circuit, no current passes, as the electro-motive forces, due to the contacts of dissimilar metals, exactly balance each other. If some of the junctions are made warmer than the others, the balance is destroyed. Nobili's thermopile is based on this principle, and is a kind of thermometer. The *neutral point* for every two metals is that point at which no current is given when one end is as much above the neutral point as the other is below it. The metals usually used are antimony and bismuth.

Galvanometer. — The principle of this instrument depends on the fact that a magnetised needle can be deflected from the meridian by an electric current. The deflection of the needle is given in Ampère's rule. If you look towards the needle, and the current be *supposed to enter at your feet and come out at your head*, you will see *the north-seeking pole deflected to your left*, and the south towards your right. The fact, discovered by Oersted in 1819, is that a fixed current exerts at a distance a deflective action on a magnetic needle.

TEMPERATURE.

The student must early and clearly fix in his mind the important distinction between *Heat* and *Temperature* —the former is a thing, something objective; and the latter, a mere *condition* of the body temporarily heated. The temperature of a substance or of the atmosphere is measured by a thermometer—an instrument consisting of a bulb and a long fine stem, containing either mercury for the measurement of high, or absolute alcohol for very low temperatures. Certain precautions have to be taken in the manufacture of these instruments. They should not be graduated for a year or two after they are filled, to allow of the full contraction of the glass. If graduated soon after filling, thermometers read too high after the lapse of a few months. This is known as the *change of zero;* but this change is less in spirit than in mercurial thermometers, owing to the greater expansibility of spirit, which renders any slight change in the glass of little consequence. Spirit thermometers are slower in their action than mercurial thermometers, owing to (*a*) larger size of bulb, and (*b*) greater thermal capacity of the liquid. Owing to the greater expansibility of spirit at high temperatures, the degrees of a spirit thermometer, when compared with a standard mercurial thermometer, will increase in volume in proceeding from the bottom to the top of the scale. For scientific accuracy, the tubes should be *calibrated* by passing a small quantity of mercury along the tube, and marking the length occupied by this column in the different parts, allowance being made by the maker for these variations when he finally graduates the tube.

Of the thermometer there are two modifications—one being used to show the greatest heat, and known as the *maximum thermometer;* the other, the greatest cold, and known as the *minimum thermometer.* They may both be made self-registering. The *minimum thermometer*

is read by noting the degree on the scale at which the end of the index furthest from the bulb is lying. To read it at the end *nearest* the spirit, is to give the temperature at the *time* of observation, not the lowest. In Rutherford's *maximum* thermometer, read the scale at the end of the index next the bulb. In the other *maximum* thermometers, read as for the minimum.

In the use of the thermometer, certain precautions are necessary. In spirit thermometers, a small portion of the spirit may evaporate and condense in the top of the tube, producing an error of from 3° to 8°. In the mercurial, even with the greatest care, a small quantity of air is not infrequently found at the top of the mercury, which, when heated, expands and causes the thermometer to register a few degrees lower than the actual temperature.

Solar Radiation Thermometer.—A thermometer with a blackened bulb, enclosed in a glass case deprived of air. The thermometer is exposed to the sun, and placed 4 feet above the ground. It is made self-registering. The Rules for reading it are :—

1. Note the maximum temperature which it registers.
2. Subtract from this the maximum temperature given by a thermometer in the shade.
3. The difference is set down as the greatest amount of solar radiation indicated during the day.

Terrestrial Radiation Thermometer.—A thermometer protected by a glass shield, placed a few inches above the ground. It is also made self-registering, and registers the degree of cooling by radiation from the ground.

Directions for taking Observations with the Thermometers when "Stevenson's Louvre Boarded Box" is used.

1. Let down the lid of the thermometer-box, and on no account touch the thermometers.
2. Read the dry and wet bulb thermometers first.
3. Read the minimum thermometer by noting the degree on the scale corresponding to the farthest end of the index from the bulb.

4. Read the maximum thermometer by noting the degree on the scale corresponding to the nearer end of the index to the bulb in Rutherford's thermometer.

5. In Negretti and Zambra's, or Phillips', read the scale at the end of the mercury farthest from the bulb.

6. Re-set the thermometers, and close the box.

In estimating the range of temperature, certain precautions are necessary —

(*a*) *Height of Thermometers above the Ground.*—In all cases it would be as well to decide on a standard height for placing the thermometers, as the reading of two observers may differ from this cause alone. The nearer the ground the higher the temperature marked.

(*b*) *Degree of Direct or Indirect Radiation.*

(*c*) *Position of the Box.*—The nature of the soil, the covering of the ground—grass, sand, etc., Higher over long than short grass, higher over sand than grass, etc.

(*d*) *The Circulation of Air through the Box.*—Greater or lesser, according to the ventilation.

Causes of Interchange and Variation of Temperature.

By *Conduction*, *Convection*, and *Radiation*, an interchange of temperature among bodies heated to different degrees takes place, by which they undergo modifications of opposite kinds. The hottest grow cooler and the coldest grow warmer till a state of equilibrium is reached. At this point they are said to be of the same *temperature.* If they are again heated, the temperature is said to *rise*—if they become colder, to *fall.*

Conduction.—The communication of heat from particle to particle in the same body. It differs from radiation in—

(*a*) Being gradual and not instantaneous.

(*b*) It does not follow the law of rectilinear transmission, as the propagation of heat is as rapid along a twisted as through a straight bar.

The best conductors are therefore the metals, solids better than liquids, and liquids better than gases.

The practical inference from the above considerations is that dense soils are better conductors of heat than porous soils, the latter holding large quantities of air between the particles. Thus, loose soils are—

(*a*) Subject to higher temperatures.
(*b*) A greater degree of frost *near* the surface.
(*c*) The frost does not penetrate so deeply as in compact soils.

The knowledge of these facts would determine the depth for the laying of water pipes, etc.

The following Table, compiled from Buchan, being the result of nine years' observation in Scotland, is important:—

	Temperature 3 inches below surface.	Temperature 12 inches below surface.
Loose sandy soil	26·5°	32° seldom reached.
Stiff clay soil....	28°	32° frequently reached.

Schübler, taking 100 as a standard, has arranged the absorbing power of certain soils for heat thus:—

Sand mixed with lime, 100; pure sand, 95·6; light clay, 79·9; heavy clay, 71·11; pure clay, 66·7; pure chalk, 61·8, etc.

Air charged with vapour, although it mitigates the heat of the solar rays, and retards the cooling of the earth by radiation at night, is a better absorber and better radiator than dry air. This accounts for the greater apparent coldness of the air at the breaking up of a frost than during the frost, the heat from our bodies being first absorbed and then radiated into space. Snow containing a large amount of air in the interstices of the flakes protects the ground from the invasion of the frost, and prevents the radiation of heat from the earth, thus helping to preserve the roots and bulbs of plants.

Convection.—The mode by which heat is transmitted through a fluid, depending on the alteration in the density of the particles, which causes them to rise from the bottom to the surface, or *vice versa*. To convection is due the phenomenon known as "boiling," and the constant movement in the atmosphere to which we apply the term wind, and also the currents of the ocean. The heated particles of air at the surface of the earth rapidly rise, leaving a space into which the colder air from the poles flows, and wind is the result. Ocean currents are due to the same process.

Land and Sea Breezes.—When two neighbouring regions are at different temperatures, a current of air flows from the warmer to the colder in the upper strata of the atmosphere; and in the lower strata a current flows from the colder to the warmer. Land and sea breezes are the result of this law, and may be thus explained. The land during the day becomes warmer than the ocean, and, imparting its heat by radiation to the superincumbent air, the warmed air rises to allow the colder air from the surface of the sea to take its place. During the night, the land and sea both grow colder, but the former more rapidly than the latter, owing to the high specific heat of water, and the relative temperatures of the two elements being now reversed, a breeze blowing from the land towards the sea is the result.

Trade Winds.—Due to the law just explained, the atmosphere at the equator being at a higher temperature than at the poles, there is a constant tendency for the colder air to flow into the space left by the ascending current of heated air, and thus to cause a wind blowing from the north southwards to the equator, and from the south northwards, or rather towards the equator. This is just what would occur if the earth were stationary; but as the earth moves round from west to east, with varying velocity from the equator to the poles, the air

flowing from the north is forced into an oblique direction from north-east to south-west. On the south side of the equator, due to like causes, the direction of the wind would be from south-east to north-west.

Radiation.—The propagation of heat from one body to another across an intervening space is known as radiation.

In meteorology we have to consider radiation under two heads—*solar radiation and terrestrial radiation.*

SOLAR RADIATION.—The heat-rays from the sun falling on the land are arrested at the surface, the amount of absorption depending upon the conducting power of the soil, but on water the rays penetrate to a considerable depth below the surface.

TERRESTRIAL RADIATION.

1. LAND.—The heat received by the earth is again radiated from it, and as a result of this alternate absorption and radiation, the mean temperature of the earth seldom varies. As soon as the sun disappears below the horizon, the earth begins to radiate heat into space, and thus to become chilled. This chilling proceeds slowly at first, but as the earth radiates more heat than it receives from the strata of air nearest to it, the chilling process becomes more rapid. This chilling is, however, soon arrested either by the return of the sun or by the action of the following causes :—

(*a*) The surface of the earth receives a certain amount of heat from the air in contact with it, and also by radiation downwards from the air above.

(*b*) The deposition of dew, by which a large amount of latent heat is set free.

(*c*) Clouds radiate back the heat to the earth. The loss of heat from the earth is therefore less on cloudy nights, especially if the clouds hang low.

(*d*) The amount of vapour in the air also obstructs radiation; hence, the drier the air the colder the night.

(*e*) During calm nights, the earth is more rapidly cooled than when there is any wind. This may be accounted for by the fact that the earth comes in contact with the air of the upper as well as of the lower strata of the atmosphere, owing to the agitation caused by the wind.

(*f*) The degree to which the temperature of an object is reduced by radiation is proportioned to the amount of sky exposed to the free view of the object. Mr Glaisher found that a cloud passing over raw wool, greatly cooled by radiation, raised the temperature of the wool 1° per minute.

2. WATER.—The radiation of heat from water is modified by the following causes:—

(*a*) Its great specific heat.—It therefore cools more slowly than the land.

(*b*) The particles of water as they cool sink, allowing warmer portions to rise to the surface.—This process of the sinking of the cold water and rising of the warm is very slow.

Thus, the temperature of the surface of water can only be lowered by the temperature of the whole mass falling, which will of course require a longer or shorter time, depending on the depth of the water.

As a result of the above, the temperature of the air on the surface of the water is not so quickly lowered as on the land. The temperature of the sea near the surface only varies on the average about 0·6° in the day, while on the land in Scotland the air varies 12° on the average (BUCHAN).

Hourly Variations of Temperature.—Due to the distance of the sun from the horizon, the temperature of a place varies from hour to hour. Twice in the day the temperature is at the mean, that is between 9 and 10 A.M. and 9 and 10 P.M. The daily *minimum* occurs about an hour before sunrise, and the daily *maximum* about two hours after noon.

The mean temperature of a *day* is absolutely determined at Greenwich by marking the height of the thermometer every moment of the day by the aid of photography. This may also be roughly estimated in several ways :—

1. By taking the mean of the readings of the thermometer for every hour of the day.

2. By taking the mean of the maximum and minimum readings on the same day of the thermometer placed in the shade.—The mean found by this plan is, however, a little greater than the true mean.

3. From two hours of the same name.—Thus the means of two observations at 8 A.M. and 8 P.M., 9 A.M. and 9 P.M., do not differ much from the true mean.

4. From three daily observations.—The best hours for observation are 6 A.M., 2 P.M., and 9 P.M.

The highest temperature of a day is about an hour or two after noon—that is, at a time when the heat lost each instant by radiation is just equal to the amount of heat received from the sun.

The mean temperature of a *month* is found by dividing the sum of the daily means by the number of days.

The mean temperature of a *year* is found by adding together the monthly ranges, and dividing them by twelve.

The mean temperature of a *place* is determined by adding together the mean temperature for several months, and then dividing by the number of months during which the observations have been taken.

Temperature of a place modified by :—

1. *Geographical Position.*—Temperature diminishes from the equator to the poles. On the eastern side of the Atlantic the mean temperature is greater than on the western side.

2. *Land and Water. Forests and Deserts.*

3. *Elevation above Sea-level.*—When the sky is clear, the fall in temperature, up to about 5000 feet, is 1° in 239 ; with a cloudy sky, 1° in 271 feet.

4. *Mountains and Valleys.*

Isothermal lines are lines drawn on a globe or a map through places having the same mean annual temperature. It must be borne in mind that isothermal lines only give us the *mean* temperature, not the actual variations of temperature; for a country with a very cold winter and very hot summer may have a mean equal to that of a more equable climate.

Temperature Increases with Height during Cold Weather—Why?

From the experiments of Mr Glaisher and others, it is found that the temperature in cold weather at night is higher some feet above the ground than it is on the surface. The mean temperature marked by the thermometer at 4 feet was 7° higher than the mean of the thermometer placed on *long grass*. This apparent contradiction to a well-known law, that the temperature *decreases with the height*, is found to depend largely on the physical configuration of the land, and is only marked in dry, clear, calm weather during winter. In windy, stormy weather, the ordinary law takes effect.

Take, for instance, an undulating country of hill and dale, with here and there portions of table-land. Terrestrial radiation, although present over the whole surface, will however, in some parts, be modified in degree and intensity. Cold air, being denser than warm air, will tend to gravitate towards the valleys. The hot air from above, coming in contact with the chilled surface of the hill side, will become chilled by contact with the cold surface and glide down the mountain side. Thus, habitations situated on the slopes of hills have a higher mean temperature than those situated in the valleys. We also learn from this, why fogs are more frequent in low-lying districts than over the higher ground. Plains and table-lands are not affected by the foregoing considerations. Of course,

the lower we descend the colder will be the downward current of air, because it will be cooled in proportion to the extent of surface along which it has flowed.

The valleys, from this cause, act as reservoirs for the cold air gliding down the hill sides. The currents of cold air will, like all other fluids, flow down the gorges and ravines where there is least resistance to their course. Hence, frosts are severe in valleys.

The foregoing statements will explain why Swiss villages, generally built on eminences rising out of the hill sides, and bounded on both sides by gorges and ravines, are admirably protected from the cold of winter.

In choosing a health resort for invalids during the winter, the best places are those situated on gentle acclivities having a southern aspect, and well supplied with terraces, to permit of the enjoyment of out-door exercise without the exertion of climbing up steep ascents. A flanking of trees above the station has also a beneficial effect.

Glaciers.—These are rivers of ice draining the high snow fields. The movement of a glacier is essentially of the same kind as that of a river, the central portions moving faster than the edges. The movement is, therefor, one of degree not of kind. The motion of a glacier has been explained by supposing that the ice forming the glacier is successively fractured and frozen. Thus "when a glacier is forced over an obstacle, the ice, being brittle, cracks and snaps; but the enormous pressure of the sliding mass behind squeezes it together again, and *regelation* immediately heals the fractures." By alternately crushing and squeezing a block of ice it can be made to assume a variety of forms. Faraday applied the term *regelation* to the phenomenon witnessed when two pieces of damp ice are pressed together and they become welded.

Ground Ice in Rivers.—Sometimes ice may be formed at the bottom of rivers. This is supposed to be due to the mixture of the cold surface with the warmer deeper water, till the temperature of both is reduced to the freezing point. Owing to the slower motion of the deeper water, ice is formed on the surface of the river bed, clinging round small stones, etc. When the temperature of the water rises, the masses of ice break off and float, carrying with them a freight of gravel, or even stones weighing eight pounds, which are ultimately dropped into the bed of the river some distance lower down.

PRESSURE OF THE ATMOSPHERE.

THE BAROMETER.—This instrument is founded on the well-known law, that *every surface exposed to the atmosphere sustains a normal pressure equal, on an average, to the weight of a column of mercury, whose base is the surface, and whose height is thirty inches.* The pressure of the atmosphere at the level of the sea is 14·7 ℔s to the square inch. Mercury is taken as a standard, for it is found that, other things being equal, the heights of columns of different liquids vary according to their densities; thus, taking the density of water as 1, and mercury 13·59, the column of water sustained would be 13·59 times as much; that is, $30 \times 13{\cdot}59$ inches, or about 34 feet. A barometer 34 feet high would be most inconvenient. A mercurial barometer is, therefore, more portable; besides, the water barometer labours under another important disadvantage. The space in the tube above the water is not a true vacuum, as it very nearly is in the mercurial barometer. The pressure on the water at the top of the tube, due to aqueous vapour, varies with the temperature from half-an-inch at 32° to a foot at 75°. Mercury also gives off vapour, but the pressure is so slight that it need not

be considered. The space between the mercury and the top of the tube is known as the *Torricellian vacuum.*

A barometer, in its simplest form, consists in a glass tube thirty-three inches long, closed at one end and open at the other, filled with pure mercury, and then inverted with its open end downwards in a vessel containing mercury, care being taken that no air be allowed to enter the tube. The tube thus filled, fixed in a vertical position to a graduated scale, forms the barometer in ordinary use.

The following are the precautions to be adopted in filling the barometer:—

1. *Purity of the Mercury.*—Purified by washing in dilute acid, and subsequent distillation. Impurity affects the density of the mercury, and also causes it to adhere to the sides of the tube.

2. *Perfect Dryness of the Tube.*—Any moisture rises as vapour to the top of the tube, forms an atmosphere, and depresses the mercury.

3. *The Mercury should be Boiled to Expel Air and Moisture.*—The mercury should be boiled in the tube in successive portions till full.

4. *The Tube should be 33 inches long, and of equal calibre.*

To Test the Barometer, gently incline the tube, so that the mercury may strike against the closed end. A sharp metallic click will be heard if air be absent, a dull sound if it be present.

The foregoing is a description of the barometer in its simplest form; but for practical purposes, where great nicety is required, certain modifications are necessary.

KINDS OF MERCURIAL BAROMETERS.

The Siphon Barometer.—A tube of equal calibre filled and bent in the form of a siphon, so that one leg is longer than the other.

THE CISTERN BAROMETER.—The tube, as before described, filled and inverted in a vessel containing mercury, the whole fixed to a scale. On this system Fortin's barometer is made, and is so constructed as to avoid the necessity for "capacity correction."

Sources of error of the ordinary cistern barometer are—(1) Capillarity. (2) Capacity. (3) Temperature. (4) Height.

1. *Capillarity.*—The effect is to depress the column of mercury. This depression varies with the internal diameter of the tube—

$\frac{1}{2}$	inch	the error is	·003	inch.
$\frac{1}{3}$	"	"	·012	"
$\frac{1}{8}$	"	"	·070	"

To rectify this, an addition has to be made to the observed height, and special tables have been prepared for this purpose. Capillarity error is always additive. This error is only half as great when the mercury has been boiled in the tube, as when this precaution has been neglected. The error increases with the diminished diameter of the tube.

2. *Capacity.*—This error is the result of the rising and falling of the mercury in the tube, and the consequent ever-varying level of the mercury in the cistern. The correction for this error is only necessary when no provision has been made for adjusting the mercury in the cistern to the zero point of the scale. The maker should mark the neutral point, and state the ratio of the interior area of the tube to that of the cistern—thus—*Capacity*, $\frac{1}{50}$. From these data the correction is made by taking a fiftieth part of the difference between the height read off and that of the neutral point, adding it to the reading when the column is higher, and subtracting it from the reading when it is lower, than the neutral height. In barometers without the

proper adjustment, there is a certain point on the scale at which the mercurial column stands when the mercury in the cistern is at the correct level. This is known as the *neutral point.* If any mercury be lost, or added, the neutral point is altered.

3. *Correction for the Temperature.*—This becomes necessary, as the mercury in the tube expands with heat, as does also the brass scale.

The following formula may be used to make this correction :—

h = observed height of barometer in inches.

t = temperature of attached thermometer.

m = expansion of mercury per degree—viz., ·0001001 of its length at 32°.

s = linear expansion of brass scale—viz., ·00001041, normal temperature being 62°.

$$\text{Correction} = -\ h\ \frac{m\,(t - 32^\circ) - s\,(t - 62^\circ)}{1 + m\,(t - 32^\circ)}$$

Or the correction may be made by dividing by 9990 the difference between the observed temperature and 32°, and, as the temperature is above or below 32°, subtracting or adding the result to the observed height of the barometer.

4. *Correction for the Height.*—As the density of the atmosphere diminishes as we ascend, it becomes necessary to make an addition to the barometric readings for every height above the level of the sea, the temperature at the time of the observation being noted, and the necessary correction made. If the air had everywhere the same density as at the level of the sea, the problem would be very easy; but it is found that the density diminishes very rapidly as we ascend—in fact, *as the heights increase in arithmetical progression, the pressures diminish in geometrical progression.*

In the siphon barometer the errors of capillarity and capacity do not exist, but it labours under the

following disadvantages :— That the height of the mercury in the long and in the short arm have to be observed, complicating matters by admitting a considerable error in the two readings; and also that the mercury in the short arm is exposed to the air, and may thereby suffer contamination from dust and moisture.

The ordinary weather-glass, or wheel barometer, is a siphon barometer fixed in a frame. On the mercury in the short arm a float is placed, to which a string is attached which is passed over a spindle, and kept tense by a small weight. As the mercury rises or falls the float rises or falls also, and thus a backward and forward motion is communicated to the spindle, causing the index attached to point to 'fine,' 'wet,' 'dry,' etc., marked on the dial. The drawbacks to this instrument are connected with the amount of friction of the additional apparatus. These barometers or weather-glasses are of little use for scientific purposes; for it is not so much the *absolute* height, as the actual rising and falling of the mercury, which determines the kind of weather likely to follow. Cold dry air is the heaviest and warm moist air the lightest possible arrangement. Thus, in this country, a south-west wind generally brings rain and a falling barometer, and a north-east wind fine weather and a rising barometer. One volume, 11·2 litres of air weighs 14·4 grams., and one of watery vapour only 9 grams. The watery vapour in the air is in reality *water in a gaseous state* and not vapour as we see it in visible steam.

The Vernier.—This instrument is used for measuring the fractions of a unit of length on any scale. Used with the barometer, ten divisions of the Vernier are equal to eleven on the barometer scale; and as these ten are all equal to each other, it follows that each division of the Vernier must be equal to $1\frac{1}{10}$ division of the barometer scale, or $\frac{11}{100}$ inch. If, therefore, any division of the Vernier coincide, or is in a line

with a division on the scale, the lines immediately above or below those which coincide will be separated by a distance exactly equal to $\frac{1}{100}$ inch; the next two divisions either way will have a deviation of $\frac{2}{100}$ of an inch, and so on. To use the Vernier, we first notice the height of the mercury column by the fixed scale, which we find to be more than 29·5 inches, but less than 29·6; we then place the zero, or top of the Vernier scale, on a level with the top of the mercury. We may then observe, for instance, that only one of the lines of the Vernier coincides with a line on the scale, and this line is that marked 6 on the Vernier. Now, as from the top of the mercury to these lines which coincide, there are six which do not, and as each pair deviates by $\frac{1}{100}$ of an inch more than the pair below it, the top pair must deviate by the $\frac{6}{100}$ of an inch. Hence we get the reading of the mercury, which is 29·5 inches and $\frac{6}{100}$ of an inch or 29·56. The Vernier is, of course, movable along the barometric scale.

The Aneroid Barometer.

The principle of action of every aneroid barometer is that of measuring by pressure upon a vacuum chamber the weight of the atmosphere above the instrument at the time of making an observation. This pressure on the metal box is communicated from the box by a series of springs to an index traversing a graduated scale. For this reason, when we apply the instrument to the measurement of altitudes, we have to encounter the difficulty of a continual change that is going on in the atmosphere at any given station, by the effects of moisture and wind; therefore, a scale of heights placed upon the aneroid can only give a scale of *differences of heights* for one given pressure. Nevertheless, with care, very accurate results may be obtained.

Variations of the Barometer.—These may be divided into periodic and non-periodic or irregular. The diurnal

is the most marked of the periodical variations, and is most regular in the tropics. "Their regularity is such, that, in the day-time especially, we may infer the hour from the height of the column of mercury, without being in error on an average more than fifteen or seventeen minutes" (*Humboldt's Cosmos*). On the other hand, the barometer is almost constantly in motion in the middle latitudes, so that the periodical movements can only be detected by taking the mean of a long series of observations.

The Monthly Oscillation.—The difference between the greatest and least heights of the barometer during a single month.

The Mean Monthly Oscillation.—This is found by combining observations extending over a great number of years. This oscillation is least over the equator, but increases as the poles are approached.

The *Height* of the barometer is influenced by the direction of the wind, and also by the position of the moon, but this latter is very slight.

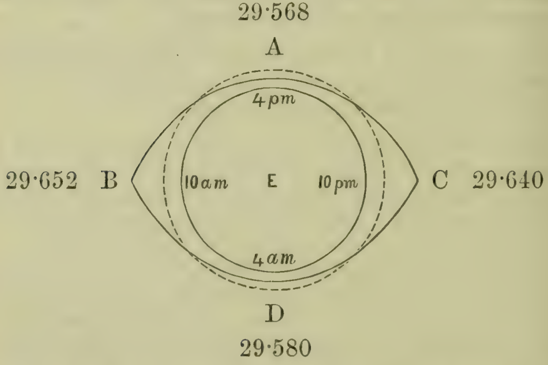
The *Monthly Means* vary, being generally less in summer than in winter, due partly to the annual range in temperature, and partly to increased rainfall, especially near the equator and the parallel of 64°.

Influence of Temperature and Vapour on the Barometer.—The barometric pressure of the atmosphere depends to a great extent upon temperature and hygrometric condition. When air is heated it expands in volume, and becomes diminished proportionally in density. When the vapour of water is added to air the effect of heat is also to expand the mixture and reduce its density. These two causes combined produce certain diurnal variations of atmospheric pressure, which are indicated by two maxima and two minima of the barometric column. The maxima pressures are found to occur about 10 A.M. and 10 P.M., and the minima

about 4 P.M. and 4 A.M. It is observed, however, that the maximum at 10 A.M. is greater than that at 10 P.M., and that the minimum at 4 P.M. is more marked than that at 4 A.M.

It is perhaps somewhat difficult to account completely for this phenomenon, but the following explanation may probably be nearly correct, and help to indicate the manner in which the sun acts more by its heat than by its attraction in heaping up two opposite and equal protuberances of the atmosphere, and thus producing atmospheric *solar* tides :—

Assuming the earth E to be surrounded by an atmosphere perfectly homogeneous in respect of moisture, and uniform in temperature, then the barometric pressure would obviously be indicated by a concentric circle



dotted in the diagram, being uniform all round the earth. If now a portion of the atmoshpere at A were more or less heated and charged with moisture, its volume would be increased, and it would therefore rise in height and overflow in both directions, piling up, on each side of A, a wave of increased pressure. The barometer would then show a minimum reading

at A, and a maximum at B and C, on each side of it. The intermediate point D, though not really affected, would present itself as a minimum in relation to B and C. Now, if we suppose the earth, with its atmosphere in this condition, to make its diurnal revolution, this condition of two maxima with two intermediate minima of pressure would recur at each successive point of the earth's surface following the apparent motion of the sun. At 4 P.M., just after the sun has been giving its greatest heat, and producing the greatest amount of evaporation, and after the column of air elevated thereby has had time to overflow, the most marked minimum—namely, that at A—presents itself. This would determine the two maxima B and C to be about six hours before and after A respectively—that is, at 10 A.M. and 10 P.M.,—and between them we should find the secondary minimum D about 4 A.M. The above must simply be taken as an attempt to explain a most important and difficult problem.

Influence of Sea and Land.—It appears from observation, that during the month of July in the northern hemisphere the lowest pressures are distributed over continents, the depression being greatest the larger the continental mass, and that it is over the ocean that the highest pressures prevail, especially over those parts which are for the most part land-locked.

Low Pressure in the Northern Hemisphere over Continents.— This low pressure is the result of the more rapid heating of the land as compared with the ocean, owing to the greater specific heat of the latter. The air quickly heated by radiation from the land rises and overflows, diminishing the pressure near the surface of the land. The frequent precipitation of vapour in the form of snow, as before shown, by letting free a large amount of latent heat, also lowers the pressure, upward currents of air being produced. The low pressure over Asia amounts to nearly half-an-inch.

High Pressure over Ocean in Southern Hemisphere.—During the same season the pressure in the southern hemisphere is increased, for the hot air, rising from the northern continents, flows over in the higher regions of the atmosphere southwards, and proportionally increases the barometric pressure there as it sinks and flows over the southern oceans. The like takes place over the oceans of the northern hemisphere; hence we find that the increase of pressure is most marked in the North Atlantic, due to its being more or less surrounded by land supplying *overflow* air from both sides.

In January, the whole of the preceding results are reversed.

Cause for this.—The land rapidly parts with its heat; on the other hand, the sea, owing to the greater specific heat of water, slowly cools; hence, there is a constant current of warm air continually rising from its surface in winter flowing over and becoming piled up over the land. The barometer is lowest over the land in the hemisphere where summer prevails, and highest in that where winter prevails, this effect being due, to a great extent, to the annual range of the thermometer.

Elevation above the Level of the Sea.—When a barometer is elevated above the level of the sea, the column of mercury sinks, due to the diminished weight of the air; for as we rise in the atmosphere, the density of the air is lessened. Due to this fact, elevations above the sea-level may be calculated—a fall of one inch in the barometer indicating an elevation of 872 feet.

Areas of Equal Pressure.—These are joined together by lines called *isobarometric lines*, or simply *isobars*, that is, lines of *equal pressure.*

Areas of High Pressure.—Two bands passing round the earth, one north and the other south of the equator, and enclosing the tropical band of low pressure.

Areas of Low Pressure.—One round each pole, besides the tropical band just mentioned.

Barometric Pressure affected by Rainfall.—During a sudden fall of rain an enormous quantity of latent heat is disengaged, and a consequent rarefaction of the air takes place, with low barometric pressure. The frequent and rapid falls of snow in high latitudes also accounts for the low barometer and variable winds; for the polar zones have not, as the equatorial zone has, the powerful action of the sun to produce aerial currents.

Barometric Gradients.—If the readings of barometers at several stations be taken, their variation will form a gradient. It must be remembered, however, that the vertical scale is measured in hundredths of an inch of barometric pressure; the horizontal, in miles of distance or degrees of 60 nautical miles. A gradient of 4 means that the barometer rises $\frac{4}{100}$ or $\frac{1}{25}$ in 60 miles or one degree. The further the isobars are apart, the lower the gradient and the lighter the winds. The air, forming a wind, does not move *directly* from regions of high pressure to those of low pressure; but for the northern hemisphere, the law laid down by Buys Ballot may be taken as showing the relation of winds to pressure.

The Use of the Barometer in Mines.—It appears that "when the barometer indicates a fall, the thermometer a rise, and the wind from the E.S.E. or south (in England), an ordinary fiery colliery will be certain to pass rapidly into a state of great danger. The fall of the barometer is a sure presage of increasing discharge of inflammable gas; for when the barometer stands steadily—say at 29°—and the pressure is uniform, nothing exudes but the ordinary 'makings' of the mine; but when a sudden fall of the barometer portends a lightening of the atmosphere, and consequently a pressure upon the orifices whence the gas escapes, or upon the main body accumulated in the waste, then

it is that extraordinary eruptions take place, enough to overpower and adulterate even the main current of air, and consequently to subject the mime to explosion."

Influence of Barometric Pressure on Sewers.—The lowering of barometric pressure causes an escape of the sewer gases pent up in the sewage, whereas an increase of pressure acts in a contrary manner, confining, as it were, the gases in the sewage. Hence, drains stink when the barometric pressure is low; and this effect on the drains may be frequently noticed after a shower of rain.

Buys Ballot's Law.—"If at the same moment of time there be a difference between the barometrical readings at any two stations within a reasonable distance from each other, a wind will blow on that day in the neighbourhood of the line joining those stations, which will be inclined to that line at an angle of nearly 90°, and will have the station where the reading is lowest on its left hand side." In other words—"If on any day a person stand with his back to the wind, the reading of the barometer will be lower at all stations on his left hand than it is where he is at the time."

WINDS.

Wind is air in motion. Three causes are at work in the production of wind :—

1. Unequal atmospheric pressure. Winds blow from a region of higher to a region of lower pressure. In other words, cold air is heavier than hot air ; hence, temperature is the cause of wind.
2. Unequal specific gravity of the atmosphere. The result of temperature and humidity.
3. The rotation of the earth.

The rotation of the earth would not alone produce wind, but it materially affects the currents of air flowing towards the equator from the north and south poles, and drives the air in a line the resultant of the two

forces, the rotation of the earth and the flow of air from the poles to the equator respectively, N.E. on the north of the equator, and S.E. south of the line. The Trade winds are the result of the above causes, and extend from 7° to 29° N. for the N.E. Trades, and to latitude 20° S. for the S.E. Trades. Between these, on both sides of the equator, there is a belt of from 150 to 500 miles of calm or variable winds.

Surface Winds.—These may be divided into four systems:—

The Equatorial or Trade Winds, the Winds of the Middle Latitudes, the Polar Winds, and the Variable Winds.

Equatorial or Trade Winds.—The causes in the production of these have just been given.

Winds of the Middle Latitudes.—Over the parallel of 32° the mean pressure of the air is ·558 inch greater then over the parallel of 64°, and, therefore, at the earth's surface the air tends from the parallel of 32° toward the pole. The air in latitude 32° is indeed warmer, and therefore lighter, than it is near the poles, and this creates a tendency of the surface current from the poles towards the equator: but the effect of the increased pressure of the air near the parallel of 32° is greater than that of its diminished density, and the air actually moves towards the poles. But while moving northward it crosses parallels of latitude whose easterly motion is less than its own; and, since it retains the easterly motion it had at starting, it has a relative motion from the west, which, combined with the first northerly motion, carries it towards the north-east. Thus, throughout the middle latitudes of the northern hemisphere the prevalent motion of the lower portions of the atmosphere is from the south-west; and, for like reasons, in the southern hemisphere the lower portions of the atmosphere move from the north-west (Loomis). It is to the south-westerly winds that we owe, to a great extent, our mild and rainy winters.

Polar Winds.—Due to the rush of air to the equator from the north, and from the south to the same destination, combined with the rotatory motion of the earth. A north-east wind prevails in the Arctic, and a south-east in the Antarctic regions.

Variable Winds. — These depend on local causes, physical configuration, etc.; thus, it is found that the mean direction of the wind is N. E. at Christiania, whilst it is S.S.E. at Hammerfest, Christiansand, on the west of Norway. In the northern hemisphere southerly winds are warm and humid, and northerly winds dry and cold : the opposite is the case in the southern hemisphere. In Europe, easterly winds are cold and dry ; westerly, warm, and humid.

THE EAST WINDS OF BRITAIN.—These blow chiefly during Spring. They may be referred to the following causes :—

1. Expansion of the air in the southern hemisphere when the sun is south of the equator, and its overflow to the northern hemisphere.
2. Hence, a greater accumulation of dry air north of the equator in winter than in summer, the result of precipitation of snow, etc.
3. The high atmospheric pressure due to the low temperature over Russia in winter, as compared with the summer pressure.
4. The heating of the north of Africa and south of Europe and Asia causing the surface air to rise, with a consequent rush of air from Russia to take its place.
5. A tributary from this northerly current constitutes our east winds.

The unhealthiness of these winds is due, to a great extent, to their coldness and dryness, and want of ozone. Radiation is much more active when the air is dry than when it is moist, and therefore our bodies radiate more heat when a dry cold air is blowing over us than when the air is more or less charged with vapour ; and we, therefore, feel the cold biting east wind, which robs us as rapidly of our heat as it is generated, whilst

that portion of our bodies which is exposed to the sun is almost scorched. This comparative freedom from vapour also explains the intense heat of the direct solar rays in the polar regions, where Captain Scoresby noticed that the pitch rapidly melted on the side of his vessel exposed to the sun, whilst ice was as rapidly produced on the protected side. To like causes may be attributed the intense solar heat in Alpine regions, and the oppression felt in travelling over these regions. From the above statements the injurious effects of the east wind may be appreciated.

Monsoons—Cause, Effect on Climate, etc.—These are due to the modifying influence of land on the atmospheric changes before described, and which, in this case, so affects the Trade winds as to change the direction of their course for certain months in the year. Thus, from April to October, the prevailing winds blow from S.W.; from October to April, from N.E. This is due to the fact that during summer the southern part of Asia becomes warmer than the Indian Ocean near the equator, and thus draws the air towards it, which, coming from a lower latitude, has an excess of motion towards the east, and this, combined with the motion from the south, due to the influence of heat, produces a wind from the S.W. During the winter the reverse takes place; the ocean being warmer than the land, the usual N.E. Trade is the result. The velocity of wind varies with the latitude, decreasing in velocity from the equator to the poles. This fact will help partly to explain the increased velocity of the monsoons.

The effect of the S.W. monsoon on the climate of Southern Asia, and on Central and Western India, is most marked; for the vapour with which it is charged is condensed by the high mountains, producing heavy rains, and an increase buoyancy in the air by the heat liberated in the act of condensation, thus lowering the density of the lowest strata and increasing the velocity

of the in-rushing air. This and the before-mentioned causes explain the terrible velocity of the monsoon. The rainfall in China, from this cause, amounts to 3·34 inches in winter, and 37·70 in summer. A knowledge of the direction of these winds is also valuable as a means of inter-communication by sailing ships.

Cyclones are storms in which the motion of the wind is found to be in great circuits spirally inward toward the centre of the storm. The barometric pressure *increasing* toward the circumference of the storm. The air in cyclones has not merely a movement of translation, but also a gyratory motion about the centre of the storm. North of the equator this motion is from right to left, or in a direction *contrary* to that of the hand of a watch; south of the equator, from left to right. The parabolic course of cyclones is due to the rotatory motion of the earth. Large masses of air when put in motion in the northern hemisphere about a vertical axis, have the particles on the east side of the centre crossing parallels of latitude with an easterly motion less than their own, and are hence deflected toward the right or east. For the same reason those particles on the west of the centre, crossing parellels whose easterly motion is greater than theirs, are deflected towards the west or right. Particles on the north or south are also turned towards the right. On the equatorial side of the revolving mass of air, the tendency is towards the equator; on the polar side, towards the pole. The deflecting force increases towards the pole proportional to the sine of the latitude. The pressure on the polar side towards the pole is greater than on the side towards the equator; hence, the revolving mass of air moves towards the poles—that is, in the direction of greatest pressure. The revolving mass within the limits of the Trade winds is carried westward by the general westward motion of the atmosphere, and also northward by the causes just given; thus the actual

progress of the storm is north of west. Out of the Trade winds the storm is carried eastwards, due to the general motion of the atmosphere, and also northwards; hence, the storm moves towards the north of east. Cyclones on an average travel at the rate of 18 miles an hour, and as a rule follow the course of the prevailing winds. Cyclones are announced by a rapid fall in the barometer, especially in the centre of the storm where the wind is most violent; but as the centre itself passes over any spot, a momentary calm is observed, the wind immediately recommencing in the reverse direction to that which it had the instant before —anti-cyclone—a necessary consequence of the vorticose motion. In the anti-cyclone the highest pressure is found in the centre of the storm, and *decreases* towards the circumference. These storms, associated with warm sultry weather in summer and frost and fogs in winter, generally remain in the region in which they are formed; but the two systems, cyclone and anti-cyclone, are always in close proximity to one another. The direction of the wind in a cyclone is in a spiral form towards the centre; in the anti-cyclone from the centre.

Typhoons are the cyclones of the China seas.

Hurricanes, those of the West Indies and Southern States of America.

Whirlwinds are generated by any cause—*e.g.*, fires—which produces a strong motion of the air, spirally inward and upward, and may be as harmless as the ordinary whirlwind of our streets or as fearful in their results as the tornadoes of the West Indies. If a whirlwind is formed over water, a waterspout is produced. A whirlwind passed over Winnipeg, Manitoba, in May 1885, lifting a large volume of water from the Red River and destroying several houses in its course across the town. I happened to be an eye-witness of this interesting phenomenon.

Force and Direction of the Wind.—To determine the force and direction of the wind various forms of anemoscopes and anemometers are used. These are all modifications of the common vane, to which certain rack-work adjustments are added, and by the aid of which the force and direction of the wind may be registered. Those best known are Robinson's and Osler's anemometers; the latter registers direction, velocity, and pressure.

To Calculate Force of Wind.—Multiply the velocity for a minute by 60; square the result, and multiply by ·005. The result will give the force of the wind in pounds, or parts of a pound, per square foot.

The Velocity of the Wind.—The average velocity of the wind may be taken as nine miles an hour at Plymouth, ten miles at Greenwich, and so on—varying with the locality. Several tables of comparison for the velocity of wind—from *just perceptible* at 2 miles, to a *hurricane* at 84 or 100 miles an hour,—have been made, but the data from which they are composed appear to be arbitrarily selected.

OPTICAL ATMOSPHERIC PHENOMENA.

Light.—The speed of light is about 186,000 miles per second, and has been determined astronomically by noting that the eclipses of Jupiter's satellites do not appear to recur at regular intervals of time, a necessary consequence of the finite speed of light. Bradley has also shown that the fixed stars appear to describe small ellipses on the surface of the heavens in the course of a revolution round the sun, each star being displaced from the centre of its ellipetic path in the direction of the earth's motion in its orbit, and each to the same amount. This is supposed to be due to the finiteness of the speed of light as compared with the speed of the earth in its orbit.

Rainbows.—To the reflection and refraction of rays of light from the inner surfaces, and through raindrops, rainbows are due. Besides the primary bow, a secondary bow is often seen. The ray of light entering the raindrop forming the primary bow, suffers one reflection and two refractions, in the secondary bow two reflections and two refractions. A rainbow cannot be seen if the altitude of the sun be greater than the radius of the bow.

Blue of the Sky.—This is due to the reflection of light, the blue rays of the sunlight being more readily reflected by dense masses of air than the red rays which have a greater penetrating power. The purer the air, the more decided is the blue tint. The intensity of the blue colour of the sky is measured by Sanssure's *Cyanometer*—an instrument painted with twenty-seven shades of blue, from almost white to the deepest cobalt blue, each shade being numbered. There is also another scale, from blue to jet black, numbered from 27 to 53. The instrument is used by selecting the shade corresponding to that of the sky, and denoted by the number of the tint.

Twilight.—This is due to the reflection of the rays from the setting sun depending on the amount of the moisture and purity of the atmosphere; for in the tropics, where the air is dry and pure, twilight lasts but a short time, about fifteen minutes. If the earth had no atmosphere the transition from day to night and from night to day would be abrupt. Attempts have been made to determine the height of our atmosphere from the duration of twilight, and these calculations have placed the height at about 50 miles, but it is probable that an atmosphere of greater tinuity exists beyond the limit given. As the sun sinks below the horizon, its rays are reflected by the atmosphere, and this continues till it reaches 17° or 18° below the horizon. Twilight is said to end when stars of the sixth magnitude are visible in the zenith. The *twilight*

curve is due to the interception of the sun's rays from a portion of the atmosphere by the conical shadow of the earth, and the segment thus formed is only illuminated by the diffuse light reflected from other portions of the sky.

Twinkling of Stars.—This is due to the passage of rays of light through currents of air of different temperatures, which retard and thus interfere with the undulations of light. The image of the star is due to the action of all the rays which are not interfered with, and as the state of the atmosphere is constantly changing, the colour of the luminous points must change also. The rays of light from the planets are not as in the case of the fixed stars parallel, therefore they are less interfered with, and therefore appear to twinkle little, if at all.

Halos.—These are circles of prismatic colours seen round the sun or moon, chiefly the latter. They are due to the refraction of light by crystals of ice floating in the air. Halos are frequently accompanied with "mock suns"—*parhelia*, or "sun dogs," as they are called in Canada, generally the forerunners of stormy weather. Mock suns are of frequent occurrence during the long Canadian winters. The moon may also be accompanied by "mock moons" or *paraselenæ*. On the night of the 2nd of February 1893 a magnificent display of this phenomenon occurred in Manitoba. The moon was some distance above the horizon. At a distance on each side of the moon were two mock moons, the halves of which, furthest from the moon, displayed most magnificent prismatic colours. From the moon a circle of white light parallel to the horizon, and passing through the prismatic mock moons, was also present, studded at regular intervals with paraselenæ looking like white nodules on the circle of light. A half-circle of white light was also present above the moon.

Coronæ.—These are the coloured rings seen round the sun or moon when partially covered by light fleecy clouds. They are produced by the refraction of light in its passage through the small spaces in the condensed vapour of a cloud.

Glories.—The coloured circle seen round a person's head when thrown on a fog are known as glories, or *anthelia.* These are frequently seen in the Arctic regions. They are also due to the reflection and refraction of light.

Falling Stars.—These are portions of nebulous matter becoming incandescent by the friction generated during their passage through our atmosphere.

Libration.—As the rotation of the moon on her axis is uniform, but her motion in her orbit is not so, we are enabled to look a few degrees round the equatorial parts of her visible border on the eastern or western side, according to circumstances. Now, since the axis about which the moon revolves is neither exactly perpendicular to her orbit, nor holds an invariable direction in space, her poles come alternately into view for a small space at the edges of her disc. There are two distinct kinds of libration, and in consequence of which the same identical point of the moon's surface is not always the centre of her disc, and we, therefore, get sight of a zone of a few degrees in breadth on all sides of the border beyond an exact hemisphere.

Perturbations.—These are inequalities in lunar and planatory motions, and arise from the mutual gravitations of these planets towards each other, which derange their elliptic motions round the sun. These perturbations though insensible in short intervals may, after the lapse of ages, alter very greatly their present elliptic relations. *Evection* is the greatest of all the lunar inequalities produced by perturbation, and arises directly from the variation of the eccentricity of her orbit, and from the fluctuation to and fro in the

general progress of the line of apsides caused by the different situation of the sun in relation to that line. As a result, the moon is alternately in advance, and in arrear of her elliptic place by about 1° 20′ 30″.

Aberration.—This is a small, apparent motion of the fixed stars, occasioned by the progressive motion of light, and the earth's annual motion in its orbit. As a result of this each particular star is made to apparently describe a small ellipse in the heavens, having for its centre the point in which the star would be seen if the earth were at rest.

Eclipses. — When an obscuration of one of the heavenly bodies by the interposition of another, either between it and the spectator, or between it and the sun occurs, an eclipse results. We may thus have a lunar eclipse when the moon passes through the earth's shadow, or in other words, when the earth passes between the sun and moon. A solar eclipse occurs when the moon passes between the earth and the sun. The *ecliptic* is the track which the sun appears to follow in the heavens, in consequence of the earth's motion round it, and is so called because eclipses only happen when the moon is either on, or very near to this curved path.

2. Influence of Trees, Forests, and Sandy Deserts.

Luxurious vegetation and dense forests act by preventing the heating of the ground by the direct rays of the sun, and also by the rapid absorption of solar heat by the moisture, the result of the vital organic action of the leaves. Due also to the increased radiation from the greater exposed surface of the leaves, the amount of heat accumulated on the surface of plants is less than that of the unprotected land. Thus, vegetation acts in a threefold manner, by *shade*, *evaporation*, and *radiation.* Trees part with their heat from above downwards, and

those leaves are first cooled which are directed without any intervening screen towards the unclouded sky. A second stratum of leaves has its upper surface turned to the under surface of the first stratum, and will give out more heat by radiation towards that stratum than it can receive by radiation from it. The result of this unequal exchange will thus be a loss of temperature for the second stratum of leaves also. By this process, "a tree, the horizontal section of whose summit would measure, for example, 2000 square feet, would act in diminishing the temperature of the air equivalently to a space of bare or turf-covered ground several thousand times greater than 2000 square feet." Another effect of forests is the greater distribution of heat over the twenty-four hours in countries where the ground is thus protected, than in those where sandy deserts are exposed to the direct action of the sun. Trees, though following the same laws as other bodies as regards heating and cooling by solar and nocturnal radiation, do not, however, appear to reach their maximum of temperature till a short time after sunset. This in summer occurs about 9 P.M., while the maximum temperature in the air occurs between 2 and 3 P.M. (BUCHAN). For the reasons just stated, the change in the temperature of trees is slower than in the air, as strata after strata of leaves have to part gradually with their heat. The result of this transference of the maximum daily temperature to so late in the evening is to render the nights warmer and the days cooler, thus more nearly approaching an insular climate. It is also not improbable that forests, whilst diminishing evaporation from the damp ground under them, increase the humidity of the atmosphere; and it has been shown that in order to form one pound of woody fibre a plant evaporates 200 ℔s of water. The roots of trees also tend to retain the moisture in the soil. The heat of summer is lowered, and the cold of winter lessened by the presence of large forests. Having a lower temperature than that of the surrounding district,

forests increase the rainfall, and thus act like mountains in arresting the rain, bringing clouds and condensing their vapour into rain.

Vegetation is also a source from which the atmosphere obtains its electricity. Oxygen, charged with negative electricity, is given off by plants during the day; and carbonic acid, charged with positive electricity, during the night: the two probably neutralise each other.

From the above considerations, and from the fact that the movement of air is materially affected by forests, care should be taken to keep the growth of trees within proper limits. Stations situated in the midst of dense forests are often very unhealthy. But, on the other hand, it must be remembered that trees have a wonderful power in arresting the spread of malaria: villages separated by trees from marshes do not, as a rule, suffer from malarious diseases. Trees also protect mountain stations from descending currents of cold air.

In a hygienic point of view, Parkes divides vegetation into Herbage, Brushwood, and Trees.

Herbage is always healthy, cooling the ground, as before noticed.

Brushwood is generally unhealthy, and should be removed, as the air is almost stagnant where the underwood is very thick. The removal should be effected in the middle of the day, when the sun is hottest. The removal of brushwood *may*, however, for a time give rise to malarious diseases.

Trees should be removed with care, and in most cases only when they materially affect the proper movement of the air, as their injudicious removal might materially affect the rainfall and the supply of water. The waters of Lake Tacarigua, which were gradually receding towards the end of last century, are now increasing, due to the presence of large forests which have sprung up since the destruction by war of the peaceful operations of agriculture in the valley Aragua in Venezuela, in which the lake is situated.

Sandy Deserts.—Due to the absence of vegetation, the temperature of sandy deserts frequently rises to 120°, 140°, or even 200°. The desert of Sahara gives to the south of Europe an unduly high temperature.

3. Influence of Lakes, Marshes, and Rivers.

Lakes.—The presence of large masses of deep water surrounded by land, as is the case in North America, results in an almost insular climate in summer, and a continental one in winter; for the frozen lakes seem to exercise the same influence as if they were solid land. The specific heat of water helps, therefore, to lower the summer temperature; but the winter ice gives the same results as an equal mass of land. Deep lakes situated at the bottom of valleys are a source of heat in winter, for the cold air coming down the mountain sides cools the surface water, which sinks deeply into the water, thus scarcely affecting the temperature at the surface of the lake. The severity of the winters of the countries surrounding the Baltic is due to the shallowness and feeble saltness of that sea, which causes it to be so easily frozen over.

Marshes, on the other hand, by the evaporation of the thin layer of water, help to keep down the summer temperature. Marshes have a marked tendency to render the surrounding country unhealthy. Ague and remittent fevers are attributed to the presence of marshes in the south of Essex and at the mouths of many of the African rivers.

Rivers add largely to the moisture in the atmosphere, and, therefore, modify the climate of a place. They also partly affect the geological configuration of a country. In tidal rivers the banks are frequently very unhealthy, especially if the country through which they flow is low and subject to irregular inundations. In some rivers a peculiar phenomenon is often witnessed known

as the "bore." To explain the phenomenon as seen in the Severn, which is a tidal river, it must be borne in mind that the ordinary tidal wave in the ocean is an oscillatory wave and not a wave of translation, but if the tidal wave rolls into a narrow estuary, the water becomes heaped up and produces a sudden rush into the channel of a river producing the "bore." Thus the tidal wave becomes a wave of translation.

4. Influence of the Sea.

In considering the effect produced by the sea on the climate of a place, we have to consider—

1. *The great Specific Heat of Water.*—Water has the greatest thermal capacity for heat of all known substances. This property of water prevents the surface of the sea from being as highly heated as the land, and also retards its cooling, at the same time that it gives out more heat through a given range of temperature than the land. The amount of heat required to raise one pound of water from 0° to 100° C. would raise the same weight of iron from 0° to 900° C.; hence, a pound of water, on cooling from boiling point to zero, gives out 900 caloric units.

2. *Density.*—Water follows the law that bodies expand when heated, and contract on being cooled, till a temperature of 39° F. or 4° C. is reached, when it is at its greatest density, and from which it then begins to expand till the freezing point is reached. Water sinks on cooling, and this sinking of the cold and rising of the warm continues till the whole mass of water has fallen to 4° C. or 39° F., when further motion is arrested, and needles of ice are formed at the surface, while the temperature at the bottom remains at 4° C. or 39° F. Now, while this holds good for fresh water, certain modifications have to be considered when the water

contains salt or any other saline substance. Depending on the saltness of the water, the temperature of maximum density falls with and below the freezing point, and salt water then follows the law of expansion and contraction by heat and cold. An important fact to be deduced from these considerations is, that no ice can be formed on the surface of salt water till the temperature of the whole mass has fallen to its freezing point; but in the case of fresh water, as we have just seen, ice is formed as soon as the temperature of the mass reaches 4° C. or 39° F. The temperature of the bottom of the sea has been determined by sinking registering thermometers enclosed in strong cases to prevent their being broken by the immense pressure to which they are subjected.

3. *Currents.*—The climate of a country is more or less modified by the temperature of the sea currents which bathe its shores.

The temperature of the following countries is raised—West of Europe, East of Africa, South Asia: these depressed—East and West Coasts of North America, West Coast of South America, West Coast of Africa, East Coast of Asia, and South Coast of Australia.

The sea currents depend on the following causes:—

1. The duration and strength of prevailing winds.
2. The propagation of the tide-wave round the globe.
3. Variations of density due to changes of temperature in different latitudes, and to the relative quantity of saline contents.
4. Variations of atmospheric pressure regular in the tropics, and propagated east and west.

Of ocean currents, the most important to us in Europe is the Gulf Stream. It is, in fact, a great shallow river in the ocean, the margins of which are so well defined that Admiral Sir Alexander Milne found that the temperature at the bow of his vessel was 21·5° C.; at the stern 4·5° C.

The practical effect on the climate of Britain of a large stream of warm water flowing along its western coast is to raise the temperature 20° higher than it would otherwise have been.

Tides.—These are due to the attracting influence of the sun and the moon on the watery envelope round the earth, and thus we have solar and lunar tides. Owing to the greater distance of the sun from the earth his tide-producing value is weakened to such an extent that his effect, as compared with the moon's, is only as 4 to 9 or thereabouts. *Spring tides* are due to the fact that in the course of every lunar month there are two periods, new and full moon, when the times of solar and lunar high water coincide, and the vertical movement of the water is greatest. *Neap tides* correspond to the two periods, first and third quarters, when solar high water coincides with lunar low water, and *vice versa*, and when, therefore, the vertical movement of the water is least. In the open sea the true tidal wave is merely an oscillatory movement up or down, but in narrow channels the tidal wave gives rise to a wave of translation, and the water actually moves backwards and forwards.

5. Influence of Hills and Mountains.

In order to give some idea, on a map, of the evenness or unevenness of a country, several methods have been adopted. One method is that known as *hill shading*, the lines or *hachures* being drawn thickly and closely together; the objection to this plan is that, although it shows that one portion of the country is higher than another, it does not enable us to determine the relative heights. The other method by *contour lines* is at once more scientific and accurate. Contour lines are lines drawn through all places which are at the same height

above the level of the sea. It will, however, be thus seen that contour lines may be used whenever we wish to depict differences in temperature, pressure, magnetic variation, etc., known as *isothermals*, *isobars*, etc.

Contour lines are often formed by the subsidence of water in a lake, as in the case of the parallel roads of Glen Roy. By the use of these lines, we may show the *water-shed* of a district on a map. The term *water-shed* is used to denote the slope along which the water flows to form a river or lake; and *water-parting*, the summit of the slope. The summit of the Cotterswold Hills thus forms the *water-parting* between the *water-sheds* of the Thames and Severn. The "*crest of the water-shed*," or "the *summit of drainage*," may also be used for "*the water-parting*."

The sea-area on a map is marked by figures, or *Soundings*—a rough method when compared with the use of contour lines.

Mountain ranges act by precipitating the moisture from the winds which blow over them; thus, one side of a lofty mountain range may have a moist, humid climate, whilst on the other side, the air being thus previously dried, the winters are cold and the summers hot and sultry. The probable explanation of this is, that, on the one side, the ground is protected from excessive solar and terrestrial radiation by the moisture suspended in the air; on the other side, this protecting envelope is wanting. The westerly winds which sweep over the Rocky mountains deposit most of their moisture on the western slopes, and when they descend the eastern sides, are so dry and cold that ordinary agricultural products require artificial irrigation to raise them; as seen in a large portion of the North-west Territories of Canada, and the Western States of America. In Peru, this effect is most marked, where a barren table-land some miles in area, known as Punos, is the result of the protecting power of the Andes. Prescott states

that the ancient Peruvians preserved the bodies of their dead by simply exposing them to the cold dry air of the mountain. The great desert of Gobi is caused by the Himalaya mountains. Mountains collecting moisture from the clouds increase the rainfall, and thus produce the streams of water which flow down their declivities. The rainfall near Ben Lomond measures 91 inches.

In hot climates, the plains at the foot of lofty mountains are often most unhealthy; but the cold air rolling down the sides of snow-capped mountains renders the valleys at their base cool and pleasant. This is most strikingly noticed on the Italian side of the Alps, and also on the plains of Granada, where the cold air from the Sierra Nevada lessens the excessive heat of a Spanish summer. In selecting a mountain station for troops, the direction of the prevailing winds should be considered, for the reasons above given.

6. Influence of Efficient Drainage and Sewerage.

The health of any locality in a great measure depends upon the efficiency of the drainage. In fact, all the evidence that we can collect leads to the conclusion that "there cannot be a healthy population living over or amidst the emanations from cesspools." "Up to about the year 1815, it was penal to discharge sewage or other offensive matters into the sewers. Cesspools were regarded as the proper receptacles for house drainage, and sewers as the legitimate channels for carrying off the surface waters only. Afterwards, it became permissive; and in the year 1847, the first Act was obtained making it compulsory to drain houses into sewers."

The Public Health Act of 1848 compelled the emptying of sewers into rivers; that of 1875, and the Rivers Pollution Prevention Act, 1876, prohibit the use of rivers for this purpose.

In preparing a drainage scheme for a district, the following preliminary inquiries have to be made :—

1. The area of the district to be sewered. — This may be ascertained by a special survey. or from the Government ordinance maps.
2. The rainfall of the district, and the proportion it is intended to admit to the sewers.—The rainfall may be estimated by experiments, or by consulting Mr Symond's Tables.
3. The geological character and physical outline of the district.—Obtained from local geologists or Government maps.
4. Present and prospective number of the inhabitants.—For this purpose the future population must be estimated by rules before given.
5. The water supply of the district.—This will to some extent regulate the supply of rain water to the sewers.
6. The sanitary appliances in use or to be adopted.
7. The nature of the outfall and the method of sewage disposal.
8. A good plan of the proposed sewerage scheme to enable, in the case of stoppage, the easy finding of the sewers.

DRAINS AND SEWERS.

Drains are generally earthenware pipes properly glazed inside ; sewers may be either of earthenware or built of brick. Drains vary in size from four to six inches in diameter for houses.

In constructing sewers the following points have to be considered :—(1) The best shape. (2) The external pressure to be borne by the sewer. (3) The minimum velocity required.

When the flow is constant and large, circular sewers are the best ; but when the flow is intermittent, the oval should be adopted, so as to ensure the greatest velocity with the smallest volume of sewage. Circular sewers up to eighteen inches in diameter are best made of earthenware or concrete, and no public sewer should be less than nine inches in diameter.

INTERNAL DIMENSIONS OF AN EGG-SHAPED SEWER.

B = diameter of bottom of sewer.
C = diameter of top of sewer.
R = radius of sides of sewer.
D = depth of sewer.

$$B = \frac{D}{3} \quad C = \frac{2D}{3} \quad R = D$$ (MOLESWORTH.)

Sewers built of brick should be well cemented, elliptical or egg-shaped, with the smaller end downwards, and with provision for sub-soil drainage to prevent percolation of soil water into them. Sewers should, if possible, be laid in straight lines, and when curves are necessary, they should not be less than ten times the cross sectional diameter of the sewer. The junction of sewers by the interposition of manholes should in all cases be adopted, but this arrangement is not applicable to back drainage owing to the necessary interference with private property. All sewers should be laid sufficiently deep to be below all cellars. In Bedford, in many cases, the sewage was known to have percolated into the cellars. Sewers should never be allowed to be more than two-thirds full. The junctions from house drains should be made so that the discharge from them is in the direction of the established current. Junctions at right angles have a tendency to cause eddies by the inflowing sewage, and thus impede the main current. The more acute the angle of entrance the better. In the construction of sewers, allowance must be made for storm waters, and for this purpose intercepting sewers should be provided. These may be so constructed that they only come into use when the flow of fluid down the ordinary sewers is excessive. They are also very useful in sea-side towns, where, for some portion of the day, the main sewers are tide-locked. "In Paris the main sewers are made with paths on each side; just above the stream a tramway runs on one side, which carries a machine

which can at once clear the bottom of the sewer; the entrance to each house drain is marked by a porcelain plate bearing a number; the owner of the house pays a small sum—three francs—annually to have his house drain kept clean."

Inclination and Velocity of the Current.—For a four-inch house drain, the inclination should at least be 1 in 92; for a six-inch, 1 in 137; for street sewers, 1 in from 50 to 300 feet, the fall depending somewhat on the size of the drain, and the nature of the liquid and solid refuse it is intended to remove. Care should be taken that the fall is equable and not broken by varying gradients. The velocity for house drains should be about 180 feet per minute, and for street drains, about 100 feet per minute. Sir Joseph Bazalgette recommends a velocity in large sewers of 176 feet per minute when running three-quarters full, 165 feet when running half full, and 146 feet when running one-third full. "The greatest discharge from a circular conduit is when it is not quite full—*i.e.*, when rather better than fifteen-sixteenths full; and the greatest velocity occurs when it is thirteen-sixteenths full." The bottom velocity in a drain differs from the mean velocity in the ratio of from ·75 to ·85—say ·80 to 1—or four-fifths.

CALCULATION OF DISCHARGE FROM SEWERS.

$$V = 55 \times (\sqrt{D \times 2F}) \times A.$$

V = velocity in cubic feet per minute. D = hydraulic mean depth. F = fall in feet per mile. A = section area.

First ascertain the hydraulic mean depth where the sewage is flowing, and the amount of fall in feet per mile.

The hydraulic mean depth is one-fourth the diameter if the pipe be running full; if the pipe be not full, it is the section area divided by the wetted perimeter.

The wetted perimeter is that part of the circle of the pipe wetted by the fluid.

To find the fall in feet per mile, measure a distance of 50 or 200 feet, and calculate fall 5280 feet = 1 mile.

Multiply the hydraulic mean depth by twice the fall in feet per mile, and take the square root. Multiply the square root by 55, and result by the section area; this will give the amount in cubic feet per minute (PARKES).

SEVERAL USEFUL FORMULÆ.

P = pressure in pounds per square inch.
H = head of water in feet.
V = velocity (theoretical) in feet per second.
g = force of gravity.

$P = H \times \cdot 4335. \quad H = P \times 2\cdot 307.$

Pressure per square foot = H 62·4.

$g = 32\cdot 2. \quad 2g = 64\cdot 4. \quad \sqrt{2g} = 8\cdot 025.$

$V = \sqrt{2gH} = 8\cdot 025 \sqrt{H}$

$H = \frac{V^2}{2g} = \cdot 0155\, V^2. \quad \frac{1}{2g} = \cdot 0155.$

To find the velocity of any given head, take the square root of twice the gravity and multiply it by the square root of the given head.

THEORETICAL VELOCITY DUE TO DIFFERENT HEADS OF WATER

V = theoretical velocity in feet per second.
v = theoretical velocity in feet per minute.
H = head of water in feet.

$V = 8\cdot 025 \sqrt{H}. \quad v = 482 \sqrt{H}.$

Example— $8\cdot 025 = \sqrt{2g}$ H = 100 feet head.

$$\begin{array}{r} 8\cdot 025 \\ 10 \\ \hline 80\cdot 250 \end{array}$$

$\sqrt{100}$ is 10

PRESSURE OF WATER AT DIFFERENT HEADS.

H = head in feet.
P = pressure in cwts. per square foot = ·557 H.
P = pressure in lbs. per square inch = ·433 H.

FLOW IN SEWERS.

X = area of sewer ÷ the wetted perimeter in feet.
f = fall in feet per mile.
V = velocity in feet per minute.
A = area in square feet.
C = cubic feet of water delivered per minute.

$$V = 55\sqrt{X \times 2f}. \quad C = V \times A.$$

USEFUL DATA.

1 cubic foot of water	=	62·425 lbs. = ·557 cwts.
1 cubic inch "	=	·03612 lbs.
1 gallon "	=	10 lbs. = ·16 cubic foot.
1 cubic foot "	=	6·24 gallons, say $6\frac{1}{4}$.
1 cwt. "	=	1·8 cubic feet = 11·2 gallons.

DISCHARGE OF WATER FROM ORIFICES, SLUICES, ETC.

V = theoretical velocity due to the head of water (from surface of water to centre of orifice).
A = area of aperture in square feet.
Q = quantity discharged in cubic feet.
K = co-efficient for different orifices.
E = velocity of efflux.

$$E = VK. \quad Q = EA.$$

VELOCITY IN STRAIGHT PIPES.

$$V = 26{\cdot}76 \frac{\sqrt{Dz}}{L}$$

D = diameter of pipe. z = altitude of the head of water.
L = length of pipe in feet.

VERTICAL JETS.

H = head of water.
h = height of jet.
D = diameter of jet.
K = co-efficient varying with ratio of diameter of jet to head.
h = HK.

Co-efficients of K.

K = ·96	when	D = H ÷ 300.	
K = ·9	"	D = H ÷ 600.	
K = ·85	"	D = H ÷ 1000.	
K = ·8	"	D = H ÷ 1500.	
K = ·7	"	D = H ÷ 1800.	

To determine the discharge in gallons, the required length of weir, and the depth of overflow :—

$$G = D \times \sqrt{D} \times L \times 2{\cdot}67.$$

$$L = \frac{G}{D \times \sqrt{D} \times 2{\cdot}67}$$

$$D = \sqrt[3]{\left(\frac{G}{L \times 2{\cdot}67}\right)^2}$$

G = gallons discharged per minute.
D = depth of overflow in inches.
L = length of weir in inches.

Thus, with two inches overflow, a weir 72 inches long disharges :—

$$G = 2\ D \times \sqrt{1{\cdot}4142}\ D \times 72 \times 2{\cdot}67.$$

$$\therefore G = 543{\cdot}7 \text{ gallons per minute.}$$

For a discharge of 694 gallons per minute, with three inches of overflow, we should require the length :—

$$L = \frac{694}{D\ 3 \times 1{\cdot}732\ D \times 2{\cdot}67} \therefore L = 50 \text{ inches.}$$

To find the depth of overflow to carry 1282 gallons with a length of 60 inches :—

$$D = \frac{1282\ G}{L\ 60 \times 2{\cdot}67} 8 \text{ then } \sqrt[3]{8} = 2 \text{ and } 2^2 = 4.$$

$$\therefore D = 4.$$

FORCE OF WATER IN MOTION.

Against a plain surface at right angles to the direction of movement :—

V = velocity of water in miles per hour.
v = velocity of water in feet per second.
P = pressure in lbs per square foot.

$$P = 2{\cdot}1\ V^2. \quad P = {\cdot}976\ v^2.$$

GAUGING WATER.

H = height of surface of water above sill in feet.
h = height of surface of water measured in inches.
V = velocity of water approaching the sill in feet *per second.*
C = cubic feet discharged over each foot width of sill *per minute.*

$$\left.\begin{array}{l} C = 214\ \sqrt{H^3} \\ C = 5{\cdot}15\ \sqrt{h^3} \end{array}\right\} \text{if the stream above sill is not in motion.}$$

$$C = 214\ \sqrt{H^3 + {\cdot}035\ V^2\ H^2} \text{ if in motion.}$$

To find the velocity of a fluid issuing from an orifice in the side of a vessel :—

$$V = \sqrt{H} \times 8.$$

H = height of head of water. V = velocity in feet per second.

To find the discharge in gallons :—

$$G = \sqrt{H} \times d^2 \times 16{\cdot}3.$$

H = head. G = gallons discharged per minute.
d = diameter of pipe.

The velocity with which water issues from the side of a vessel is the same as that of a body falling freely by gravity from any height.

H = the distance from the centre of the orifice to the surface of the water.

To calculate the volume of fluid discharged—the length of the pipe or sewer, the height or fall, and the diameter being given :—

Rule.—Divide the tabular number opposite to the diameter of the tube by the square root of the rate of inclination, and the quotient will give the volume required.

Ex.—A pipe has a diameter of 9 inches, and a length of 4750 feet, what is the discharge per minute under a head of 17·5 feet?

$$\sqrt{\frac{4750}{17{\cdot}5}} = \sqrt{271{\cdot}4} = 16{\cdot}47.$$

Tabular number for 9 inches = 1147·6.

$$\text{Then, } \frac{1147{\cdot}6}{16{\cdot}47} = 69{\cdot}67 \text{ cubic feet per minute.}$$

To calculate the diameter—the length, fall, and discharge being given :—

Rule.—Multiply the discharge by the square root of the ratio of inclination; take the nearest corresponding number in the table, and opposite to it is the diameter required.

$$\textit{Ex.}\text{—}69{\cdot}67 \times \sqrt[2]{\frac{4750}{17{\cdot}5}} = 1147{\cdot}6 = 9 \text{ inches.}$$

To calculate the head—the length, the discharge, and the diameter being given :—

Rule.—Divide the tabular number for the diameter by the discharge, square the quotient, and divide the length of the pipe by it; the quotient will give the head necessary to force the given volume of water through the pipe in one minute.

$$\textit{Ex.}\text{—}\frac{1147{\cdot}6}{69{\cdot}67} = 16{\cdot}47;\ 16{\cdot}47^2 = 271{\cdot}4;\ 4750 \div 271{\cdot}4 = 17{\cdot}5 \text{ feet.}$$

To calculate the volume of water discharged from a pipe :—

$$39{\cdot}27 \sqrt{\frac{h\ d^5}{l}} = V \text{ in cubic feet per second.}$$

Ex.—The diameter of a pipe is 1 foot, the head of the flow 9, and the length of the pipe 9000 feet ; what is the volume of discharge?

$$39{\cdot}27 \times \sqrt{\frac{9 \times 1}{9000}} = 39{\cdot}27 \times \sqrt{{\cdot}001} = 1{\cdot}242 \text{ cubic feet.}$$

Discharge of Water in Pipes or Sewers for any Length and Head, and for Diameters from 1 to 12 Inches, in Cubic Feet per Minute.

Diameter.	Tabular No.	Diameter.	Tabular No.
1	4·71	4½	194·84
1¼	8·48	5	263·87
1½	13·02	6	416·54
1¾	19·15	7	612·32
2	26·69	8	854·99
2½	46·67	9	1147·6
3	73·5	10	1493·5
3½	108·14	11	1894·9
4	151·02	12	2356·0

The formula to construct this Table is as follows :—

$$\frac{2356 \sqrt{d^5}}{\sqrt{\frac{l}{h}}} = V.$$

d = diameter ; h = height of fall of water in feet.

(See HASWELL's "Mechanic's Pocket-Book.")

Man-holes and Lamp-holes.—These should be placed at convenient distances to allow easy access for examination and cleansing of sewer, and fitted with ventilating chambers filled with charcoal. Lamp-holes are small shafts, allowing of the suspension of a lamp, which may be seen from a man-hole along the sewer. Man-holes should be placed at every point of lateral deviation in a sewer, and man-holes or lamp-holes at every vertical point of deviation. Both man-holes and lamp-holes should act as ventilators.

Obstruction to Sewers.—This may be due to—

1. Improper levels used.
2. Too little fall.
3. Too sharp curves and bad connections.
4. Imperfection in the laying and making of the sewers, causing sinking of the floors.
5. Impediments at mouth of sewer from—
    - (*a*) Accumulation of mud, excreta, etc.
    - (*b*) Backward pressure of sewage, due to tides and wind.
    - (*c*) Want of proper supply of water to flush the sewers periodically.

The Cleansing of Sewers.—This should be frequently done, by flushing or otherwise, for a large amount of putrescent matter clings to the top and sides, due to the ever-varying level of the flow. The cleansing of sewers is now economically done by flushing, the old plan of breaking into the sewer and carting away the deposit being found too expensive. "The cost of removing deposit from the tide-locked and stagnant sewers of London formerly amounted to the sum of about £30,000 per annum." Where flushing is required, the rainfall must not be depended upon, for it is during the summer, when the rainfall is least, that the most injurious effects of an accumulation of filth are likely to result, increased also by the high temperature of that season. Artificial means are therefore required. In flushing sewers, commence at the lower parts of the district, and work gradually up to the higher parts.

The following Table is given by Denton:—

30	feet	per minute	will disturb clay with sand and stones.
40	"	"	will move along coarse sand.
60	"	"	fine gravel, size of peas.
120	"	"	rounded pebbles, 1 in. diameter.
180	"	"	angular stones, $1\frac{3}{4}$ in. diameter.

In some districts where it is impossible to get proper gradients, certain special appliances have to be adopted,

thus Field's Automatic Flush Tank, or Shone's Pneumatic Ejector may be used. The ejector is useful for discharging sewage into the sea or rivers against the rising tide. A sluice fixed in a sewer to regulate or control the current for flushing purposes is known as a *penstock*. It is necessary in tidal outfalls as an adjunct to tidal valves.

Ventilation of Sewers.—The difficulties in the sewerage of a town are not ended when the sewers are completed, and the sewage turned into them. The sewers have to be ventilated. The generation and escape of sewer air is effected by—(1) Barometric pressure; (2) Temperature of liquids poured into sewers. In some towns ventilation has been attempted by open gratings in the street communicating with the sewers. This was done in Southampton, but the smell from the holes was so bad that the inhabitants stopped them up, the result being that the sewer gas forced the traps and entered the houses. Little ventilation is required if the sewers have a good fall, or are "flushed" daily, but this cannot always be accomplished. Manholes may be used if a tray containing charcoal be so placed as to intercept the gases as they rise. These charcoal ventilators are now, as a rule, condemned. An attempt was made in Southwark to ventilate the sewers by pipes connecting them with the furnaces of the soap works; the result was an explosion which blew "all the furnace down." But even where explosions do not occur, it is found that this method of ventilation is uncertain, and that the draught so created is so great as to open the house-traps in the neighbourhood; "and when out of work, such inlets form outlets for the gases generated in the sewers, and therefore at such times disperse the sewer gases into the air of the streets and dwellings of the inhabitants of the district; or, in other words, such a system is violent, local, and intermittent in its application" (THORBURN). The best plan appears to be to connect

the sewers with pipes carried above the tops of the houses, with an archimedean screw, or better, Boyle's ventilator, at their tops. The pipes should be of sufficient calibre to prevent the cold of winter condensing the sewer vapours on their sides, and thus blocking them. At Tottenham, near London, the pipes are carried by the side of the chimneys of the houses, a very excellent plan.

House Drains.—These, when inside the house, should be made of cast iron, smooth inside, with caulked lead joints, and with sufficient fall to render them self-cleansing. For outside the house, and where the soil is firm and unyielding, glazed earthenware pipes may be used, the joints being fixed with hydraulic cement, care being taken that no cement stands up inside to form an obstruction. The Stanford joints, as they are made by Messrs Doulton, have been greatly recommended. Clay should, on no account, be used for the joints of drains, as it has a strong tendency to shrink, crack, and become utterly useless. A good foundation of concrete, on which to lay the drain pipes, is also absolutely necessary to prevent the settling of a portion of the pipes and the opening of the joints. A recess should be cut in the bed of the drain-pipe trench for the socket of the pipe, and then cement should be used for the packing. Every pipe should be wiped out as laid.

THE REQUIREMENTS OF A GOOD HOUSE DRAIN.

1. A fall that will give a good velocity to the current. The velocity of the current should be about three feet per second, but to maintain this velocity it would require to run half full, so that a four-inch drain would require to be provided with water at the rate of 7·85 cubic feet per minute; a six-inch with 17·66 cubic feet per minute; and a nine-inch with 39·76 cubic feet per minute (LATHAM). The above is the theoretical requirement, but in practice a greater fall will be found necessary.

2. The most polished internal surface possible.

3. Good joints, allowing of no obstacle to the passing current, and preventing escape of sewage and gas.

4. A four-inch drain will be sufficient for most purposes. For large establishments, a six-inch is ample. Any increase in size above those mentioned is unnecessary, and increases the difficulty of cleansing by flushing.

5. Adequate means for flushing the drains periodically.

6. The connections or branches should never be at right angles. All T-joints *must* be prohibited, and Y-joints substituted.

7. *Good Traps.*—These need not be more than are absolutely necessary to prevent admission of sewer gases into the house, for "every trap in the line of a waste or soil pipe is necessarily a place for sewage to be arrested temporarily, and, if the use of the pipe be not very frequent, decomposition occurs, evolving gases."

8. A ventilating trap should be placed outside the house walls, on the main house drain, after it has collected all the branches which are tributary to it, and between this point and the sewer.

9. A good firm bed of concrete on which to lay the pipes, in order to prevent the settling and breaking of the pipes, or the pipes may be bedded in concrete.

10. Good ventilation is absolutely necessary. This may be effected by placing a ventilating trap, as just mentioned, and a ventilating pipe, starting from the highest point of the soil pipe, outside the closet trap; by this means sewer gas cannot collect in the soil pipe. The ventilating shaft should be of the same diameter as the soil pipe. The water conductor from the roof should never be used, for the compression of air in the sewer is most likely to occur during a heavy rain, when the pipes are otherwise engaged in carrying off the rain water.

11. *Traps.*—The best trap is the ordinary S bend or siphon trap. It may, however, become inoperative from the following causes:—

(*a*) The curve may not be deep enough to allow a certain depth of water to stand above the highest level of the water in the curve.

(*b*) The trap may be sucked dry if the pipe be small (2 and 4 inches) by the siphon action of the pipe beyond. This is most likely to occur if there be a sudden rush of water through the trap, and the pipes be running full. Also, if several siphons are used in the course of a drain, there may be one or all sucked dry by their united action; thus, *a b c* are three siphon traps placed in the line of a drain. If the drain, when running full, have the supply of water suddenly cut off, the result will be that a vacuum is created between *a b c*; *b* will therefore untrap *a*, and *c* untrap *b*, and *c* will itself be untrapped by the vacuum on the one side, and the force of the air on the other. To prevent this unsealing action, ventilators must be placed between the traps.

(*c*) In traps not used for some time the water may have partially evaporated, leaving the trap useless.

(*d*) If sufficient water be not used to thoroughly cleanse the trap, it may become clogged, and foul gases rise from it into the house.

(*e*) Pressure of air in sewer may force it; the water absorbing the sewer gas, and then giving it out on the opposite or house side.

(*f*) A piece of cloth or other material partly arrested in the trap may unseal it by capillary attraction.

The *Mid-Feather trap* is a siphon trap, with a projection from the inner surface of the shorter curve of the siphon dipping into the water in the trap. This trap should be so made that access to it for occasional cleaning may be easy.

The *Flap-trap* is merely a hinged flap which allows the water to pass one way only. It closes by its own weight. It is used to close the mouth of drains, to prevent ingress of wind or water, and thus prevent regurgitation.

Bell-traps ought in all cases to be avoided. These are the usual sink traps. D-traps should never be used.

12. If possible a means of access to the drain pipes should be provided for the purpose of cleansing periodically.

GENERAL PRINCIPLES IN HOUSE DRAINAGE.

1. Good drains, well laid, well ventilated; and easily got at, if necessary, for cleaning, repairing, etc. No house drain should be used as a sub-soil drain.

2. Good water-closets, with separate water cisterns for their supply. All closets should be placed on an outside wall as much as possible out of the main building, in a turret or lobby, and with plenty of light and ventilation.

The pipes from the scullery should not, if possible, open into the soil pipe, as the grease chills and clogs the drain. A receptacle for grease should in all cases be provided. The bath pipe, rain-water pipes, and all other pipes, may be discharged into the open air over a grating.

4. A plentiful supply of water.

5. The prevention of leakage. This is by no means easy unless good pipes are used and great care taken in laying and jointing them.

6. Good traps.

7. Drains within the house should be of cast-iron, and be carried outside the house walls as directly as possible. Latham recommends lead pipes, as they do not rust, but they are more likely to be gnawed through by rats and otherwise injured. If bedded in mortar the lime may act injuriously on the lead. If lead is used for soil pipes, six-pound lead is the lightest that should be employed for this purpose. In no case should the drain be carried for any *distance under the basements or cellars*, for it is most difficult to prevent sewer gases from escaping even when every precaution is taken. This rule becomes more important when we remember that every house acts as a ventilating shaft for the soil beneath, and that, as the temperature of the house is higher than the external air, the tendency is to draw the gases through the smallest leak in the sewers. On the question of the ground-air under and around

houses, and the necessity for keeping it pure, Pettenkofer remarks: "They"—our neighbours—"can also poison the ground-air for us; and I see more danger in this, as air is more universally present, and more moveable than water."

8. The fewer waste pipes in the house the better, and under no circumstances should they be placed in bed-rooms.

TO TEST THE SOUNDNESS OF HOUSE DRAINS.

1. Draw up the closet handle, and notice if a flush of water passes the disconnecting trap outside the basement. If so, drain at least pervious.

2. Stop up trap, and fill pipe in the basement with water. If water remains at same level for some time, the pipe does not leak.

3. Fumes of paraffin or oil of peppermint should be passed in at the lowest part of the drain. After a time each room is visited. If no odour of the substances used be detected, the joints and traps are perfect.

4. To test the ventilation of the pipes and traps, force into the drain the fumes of paraffin, etc., under pressure, and then note if there be any smell in any room.

Water-Closets.—It appears that the use of water-closets is of very ancient date—probably of Asiatic origin; but their application to private houses is more recent. The two forms most in use in this country are the ordinary "pan closet," and the "hopper closet," but of these there are several modifications and improvements.

The Pan Closet.—This, though the most common in use, is one of the most defective and dangerous. It consists:—

1. Of a funnel-shaped receptacle of earthenware, placed under the seat.
2. The copper pan containing water, and closing the smaller end of the funnel. When the pan requires emptying it is tilted obliquely downwards by means of a lever.
3. The cast-iron box or receiver resting on the floor into which the contents of the pan are thrown.
4. A short pipe with a lead trap, put below the floor.

The objections to this form of closet are the following:—

1. The filthy condition of the receiver, which, from its position, cannot be cleaned.
2. The trap below the floor, the contents of which generally emit obnoxious gases, and which are forced upwards every time the pan is tilted and its contents poured into the trap.
3. The large reservoir of foul air formed by the receiver, and which empties itself into the room when the pan is tilted.

To obviate these evils several appliances have been suggested, but they are all more or less complex, and therefore liable to get out of order.

THE HOPPER CLOSET.—This consists of an earthenware funnel with a lead siphon trap, or better, with an earthenware trap in one piece, to which a ventilating pipe is attached. The advantages of this closet are :—

1. That the reservoir of foul air in the pan closet is dispensed with.
2. It can be easily cleaned.

The disadvantages are :—

1. The contents of the trap are directly exposed ; care is therefore required to flush it out immediately after it has been used.
2. Considerable waste of water may result from carelessness. This may be obviated by having a separate tank containing enough water for each flushing. On no account ought the supply of water for these closets to come direct from the mains.

THE JENNINGS CLOSET.—This has the advantages of the Hopper closet without its disadvantages. These are provided against by the use of a hollow plug, which, when lifted, allows all fæcal matter to be rapidly discharged, and, when down, retains a considerable quantity of water in the closet basin. The foul reservoir of the pan closet is removed, and a larger water trap than the Hopper provided with less waste.

THE BRAMAH CLOSET.—This is a valve closet with a receiver, only large enough to allow of the full action of the valve. The receiver, although smaller than the ordinary pan closet, is open to the same objections. The trouble with these valve closets is that a piece of paper etc., may unseal the valve by preventing the valve from fitting down in its seat.

PUBLIC PRIVIES.—These are generally used in poor neighbourhoods, where ordinary closets cannot be trusted to the care of the inhabitants. There is no necessity why they should continue longer in use, for trough water-closets, on the plan adopted in Liverpool, can always be kept clean by daily inspection at a small cost.

PUBLIC HEALTH ACT (38 & 39 Vict., c. 55).

Every house built or rebuilt must have a sufficient water-closet, earth-closet, or privy, and an ash-pit, furnished with proper doors and coverings ; and the Local Authority may enforce the provision of privy accommodation for houses, factories, and public necessaries, urinals, etc. They may also provide earth-closets to be supplied with dry earth, and also provide that drains, privies, etc., be properly kept.

The Public Health (Scotland) Act, 1867, sec. 40, deals with the above in much the same terms.

On a written application to a Local Authority, stating that any drain, etc., belonging to any premises within their district is a nuisance or injurious to health (*but not otherwise*), the L. A. may empower their surveyor or inspector of nuisances, after twenty-four hours written notice to the occupier of such premises, or in case of emergency without notice, to enter such premises and cause the ground to be opened, and examine such drain, etc.

If all be found in good condition, the cost of examination is to be defrayed by L. A.; but if in bad condition, occupier must do the necessary improvement under a penalty not exceeding ten shillings for every day during which he continues to make default. The L. A. may execute such works and recover cost for same in a summary manner.

"The word 'drain' means any drain of, and used for the drainage of, one building only, or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cesspool, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed.

"The word 'sewer' includes sewers and drains of every description, except drains to which the word 'drain,' interpreted as aforesaid, applies, and except drains vested in, or under the control of, any Authority having the management of roads, and not being a Local Authority under this Act."

All existing and future sewers vest in the L. A., together with everything connected with them,

Except—

1. Sewers made by any person for his own profit, or by any Company for the profit of the shareholders; and,
2. Sewers made and used for the purpose of draining, preserving, or improving land under any local or private Act of Parliament, or for the purpose of irrigating land; and,
3. Sewers under the authority of any Commissioners of Sewers appointed by the Crown.

L. A. may purchase or otherwise acquire sewers. But any person who has acquired a right to use a sewer, shall be entitled to use the same, or any sewer substituted for it.

Every L. A. shall keep in repair all sewers belonging to them, and shall make such sewers as may be necessary for effectually draining their district.

Any L. A. may carry any sewer under any turnpike road, or any street or place, or under any cellar or vault which may be under the pavement of carriage-way of any street, after giving due notice to the owner or occupier.

L. A. shall not convey sewage or filthy water into any natural stream or water-course, or into any canal, pond, or lake, until such sewage or filthy water is freed from all excrementitious or other foul or noxious matter.

L. A. may enlarge, or otherwise improve, any sewer belonging to them, and may discontinue such sewer on condition of providing

a sewer as effectual for the use of any person who may be deprived of the lawful use of such sewer.

Every L. A. shall cause the sewers belonging to them to be constructed, covered, ventilated, and kept so as not to be a nuisance or injurious to health.

Any Urban Authority may provide a map exhibiting their sewage system.

The owner or occupier of any premises within the district of a L. A. shall be entitled to empty his drains into the sewers of that Authority, on condition of his giving notice of his intention so to do, and of complying with the regulations of L. A.

Any person emptying a drain into a sewer of a L. A., without complying with the provisions just stated, shall be liable to a penalty not exceeding twenty pounds; and the L. A. may close any communication between drain and sewer, and may recover any expenses incurred by them in so doing.

Sewers may be used by owners and occupiers without district, according to mutual agreement with L. A.

L. A. may enforce drainage of undrained houses within their district into any sewer which they are entitled to use, and which is not more than one hundred feet from the site of such house; but if no such means of drainage are within that distance, then entering into such covered cesspool or other place, not being under any house, as the L. A. direct.

If notice is not complied with, the L. A. may do the work required, and recover the expenses incurred by them in so doing from the owner, or may by order declare the same to be private improvement expenses. To save expense, when several houses want drainage, L. A. may make a new sewer and divide the expense among the owners of the houses.

When any house within the district of a L. A. has a drain communicating with any sewer, which drain, though sufficient for the effectual drainage of the house, is not adapted to the general sewerage system of the district, or is in the opinion of the L. A. otherwise objectionable, L. A. may so adapt it, etc. etc.

The Public Health Acts Amendment Act 1890, provides against the throwing into any sewer or drain, any matter or substance by which the free flow of the sewage may be interfered with, and against the turning of any chemical refuse, or any waste steam, condensing water, heated water or other liquid above 110° F. into a sewer or drain so as to cause a nuisance. A drain is now defined as a "branch sewer connecting houses with the main sewer."

THE DISPOSAL OF SEWAGE.

The proposed plans for the removal and treatment of sewage are:—(1) The dry method. (2) The wet method. (3) The pneumatic system. Before discussing these methods it is well to remember that the daily amount of solid excreta per head averages $2\frac{1}{2}$ ozs., and of fluid 40 ozs. Thus, for a population of 1000 individuals, we will have daily 156 lbs. of fæces, and 250 gallons of urine, or with the same population a yearly amount of fæces 25 tons, urine 91,250 gallons.

I.—The Dry Method.

A—Moule's Dry Earth Closet. *C*—The Goux System.
B—The Charcoal Closet. *D*—The Ash-pit.
E—The Pail System.

A—Moule's Earth Closet labours under the following disadvantages :—

1. The trouble of providing a sufficient quantity of dry earth—at *least* one pound and a half for each dejection.
2. Difficulty of securing proper attention and removal of sôil.
3. The trifling commercial value of product as manure.
4. The retention of excreta in the neighbourhood of houses.—This objection may be raised against all the dry methods.

The closets are filled with pans containing dry earth, and may be used in sick-rooms, in the country, or for small communities, but their adoption will never be general. The best earths for the use in these closets are—(1) rich garden surface mould, the best; (2) peaty soils; (3) black cotton soils; (4) clays; (5) stiff clayey loams; (6) red ferrugenous loams; (7) sandy loams; (8) sand and gravel which are of no use.

The advantages of the dry earth system are—

1. The earth closet, intelligently managed, furnishes a means of disposing of excrements without nuisance, and apparently without detriment to health.

2. In communities, the earth closet system requires to be managed by the authority of the place, and will pay at least the expenses of its management.

3. In the poorer classes of houses, where supervision of any closet arrangements is indispensible, the adoption of the earth system offers special advantages.

4. The earth system of excrement-removal does not supersede the necessity for an independent means of removing slops, rain-water, and soil water.

5. The limits of application of the earth system in future cannot be stated. In existing towns, favourably arranged for access to the closets, the system may be at once applied to populations of 10,000 persons.

6. As compared with the water-closet, the earth system has these advantages :—It is cheaper in the original cost; it requires less repair; it is not injured by frost; it is not damaged by improper substances driven down it; and it very greatly reduces the quantity of water required by each household. (BUCHANAN.)

B—The Charcoal closet labours under the same disadvantages as Moule's closet.

C—The Goux system consists in collecting the excrement in tubs lined with dry absorbents. The tubs are about 16½ inches high, and 20 inches wide at the top. Some dry stable sweepings are placed on the bottom, and on this is placed a solid plug about four inches in every direction smaller than the tub. The space between the plug and sides of the tub is now packed with more dry stable sweepings or other litter, and the plug removed. The pails are distributed to the houses, and removed for emptying every two days, prepared pails being left in the place of those removed. One boy can pack about 80 tubs in an hour. The manure, as a rule, is almost valueless, and expense of removal great. This system is said to work well in Halifax.

D—The Ash-closet has the same faults as the preceding. It is, however, in use in Salford and Manchester. The ashes from house fires are used, the result being a great improvement in the sanitary arrangements of the poorer neighbourhoods and a saving of cinders and coal.

E—The "Pail" System.—In this system the excreta are collected in pails containing some absorbent or deodorising material, and regularly removed by the sanitary authority. The pails, as a rule, contain crude

aluminum chloride or cupric sulphate, and when full are emptied into a trench with fine ashes and about 30 lbs. of H_2SO_4 to the ton. The contents of the trench are turned over till dry and then sold as manure. This plan is adopted in Rochdale.

The dry method is adopted to a great extent in India, where the proper fall for the sewers cannot be obtained; and in places where there is either an insufficiency of water, or the water for many months of the year is frozen. Where this system is adopted, the excreta are passed into proper receptacles, which in some cases allow of the fluid portions draining away; in others, the solid and fluid portions are collected and emptied daily on the land.

Under all other circumstances, the water-carriage system is the cheapest, cleanest, and most convenient, but it requires for its successful carrying out—

1. Good supply of water.
2. Good drains and sewers, with careful ventilation.
3. Sufficient fall to give the necessary velocity to the current.
4. Good subsoil drainage, apart from sewers.
5. A means of utilising the sewage.

II.—The Wet Method.

This may be divided under three heads—

1. The emptying of the sewage into a neighbouring river or into the sea.

2. The addition of disinfectants and other substances to precipitate the solid matter, and then allowing the liquid portion to pass into a river or the sea, as above.

3. The use of the sewage for the purpose of fertilisation by irrigation. The means by which this is accomplished are as follow :—

(1) By subterranean irrigation.
(2) By underground pipes and hose-and-jet distribution.
(3) By surface channels, or "wide surface irrigation" as the irrigated meadows at Edinburgh.
(4) By submersion.

4. *Filtration.*—Both upward and downward filtration through sand, gravel, charcoal, sawdust, etc., have proved costly failures. A modified form of filtration has been advocated by Mr J. B. Denton, known as "Intermittent Downward Filtration," and appears to offer some hopes of being successfully adopted. The system is in use at Merthyr Tydvil, where three areas instead of one are in constant use, each capable of cleansing the whole sewage. Ridges and furrows divide the areas, and into the latter the sewage is run for one year at a time, and then remains free from sewage for two successive years and devoted to plant growth. Succulent vegetables are grown on the land in actual use. The sewage is only poured on the land during a portion of the day, so that there is a daily as well as a tri-annual intermittency. The under drains are six feet below the surface.

The Rivers Pollution Commission makes the following remarks on the method proposed by Mr Denton :—

"Sewage traversing a porous and finely-divided soil undergoes a process to some extent analogous to that experienced by blood in passing through the lungs in the act of breathing. A field of porous soil, irrigated intermittently, virtually performs an act of respiration, copying on an enormous scale the lung action of a breathing animal ; for it is alternately receiving and expiring air, and thus dealing, as an oxidising agent, with the filthy fluid passing through it. The action of earth, as a means of filtration, must not be regarded as simply mechanical ; it is chemical, for the results of filtration, properly conducted, are the oxidation, and thereby the transformation, of the offensive organic substances, in solution in the sewage stream, into fertilising matter which remains in the soil, and into certain harmless inorganic salts which pass off in the effluent water."

Dr Dyke mentions the following as requisites to the successful practice of this method :—

1. The soil of the land to be used must be porous.

2. A main effluent drain, which must not be less than six feet from the surface must be provided.

3. The surface of the soil to be so inclined as to permit the sewage-stream to flow on the whole land.

4. The filtering area should be divided into four equal parts, each part to be irrigated with the sewage for six hours, and then an interval of eighteen hours to elapse before a second irrigation takes place; each of the four parts would thus be used six hours out of the twenty-four. An acre of the land so prepared would purify 100,000 gallons of sewage per day.

By allowing fifteen gallons of sewage polluted fluid per head per diem, the amount of land required for a given population can be calculated. Five acres well under-drained to depth of six feet would be sufficient for a population of 10,000. One cubic yard will cleanse $4\frac{1}{2}$ to 10 gallons of sewage in twenty-four hours.

Of the disposal of sewage by the first plan all that can be said against it is, that it is a great waste of valuable manure, and that by it we give to the sea what ought to be placed on the land.

With regard to the second and third methods, much discussion has arisen.

Against the second it is urged, that the solid part left after precipitation possesses little, if any, fertilising properties, and that the various precipitating processes were found only to *clarify*, and not to *purify*, the sewage, the larger part—six-sevenths—of the matter, valuable as manure, going off in the effluent fluids. Besides the precipitate being almost useless, it is considerably in the way. The cost of material for precipitation is also considerable. The only probably successful plan is that of sewage irrigation.

Against the third the following objections have been raised:—

1. That the exhalations from sewage farms may become a source of disease—enteric fevers, etc. This has not been verified by experience where proper precautions as to sub-soil drainage, etc., have been taken.

2. That the vegetable growth of such farms, even when the process of irrigation is carefully conducted, is exceedingly rank, and may give rise to disease in man and animals. Dr Spencer Cobbold's theory is that the sewage brings down the eggs of the tapeworm and disease germs, and that, during the course of the sewage over the land, some of the germs adhere to the growing plants. That when an animal eats such sewage produce, the ova of the tapeworm are developed, and cysts are formed in the flesh of

the animals, which, if eaten by man in an imperfectly cooked state, the cysts then develop into mature tapeworms. His theory has, however, not been corroborated, for no cysts were found in the flesh of an ox fed on sewage-grown grass for the purpose of experiment. If the sewage be allowed to become stagnant on the grass bad results *may* follow, but not when proper care is taken.

3. That there is frequently a difficulty in obtaining sufficient land for the complete and effectual disposal of the sewage of large towns. The difficulty is increased in proportion to the size of the town, for the required land may be large, and the price considerable —one acre for every hundred and fifty persons. It must also be remembered, when irrigation is relied upon as a means of disposing of large volumes of sewage, *that the supply is continuous*, while the land is always in varying states to receive it, being in wet weather already saturated with water. The effect of this state of things is to convert the whole area of land used for irrigation into a malarious swamp. This cannot occur if proper methods of drainage are adopted. The effluent fluid comes up to the standard purity of the Rivers Pollution Commission. In England, irrigation may proceed all the year round. Another minor objection to sewage irrigation, but one which must not, however, be overlooked, is the possible contamination of the neighbouring water supply by filtration of the sewage through the earth.

The best site for a sewage farm is a gentle slope; the land must, however, not be too retentive or too porous. An acre must be allowed for every 100 of the probable population. Italian rye grass appears to be the best crop.

Chemical Methods for Defecating Sewage.

Many plans have been proposed for the defecation and purification of sewage, which, though successful in a sanitary point of view, have proved commercial failures, because the effluent from them all is essentially *sewage.*

The following are the four best known :—(1) The Lime process. (2) The Phosphate of Alumina process of Messrs Forbes & Price. (3) The Scott Sewage Company. (4) The A. B. C. process.

1. *The Lime Process.*—This process consists in the simple addition of a definite quantity of caustic lime, the amount added being in proportion to the strength

of the sewage. This precipitates the whole of the suspended matter with a certain amount of the dissolved constituents of the sewage. A fair degree of purification is thus obtained, and the effluent water is tolerably clear; but if allowed to stand for forty-eight hours, putrefaction takes place, which may, however, be delayed by the addition of chloride of lime. The precipitate possesses no fertilising properties, and is therefore, of no value.

2. *The Phosphate of Alumina Process.*—This process of Messrs Forbes & Price is a good one, but the materials used are too expensive to command success on a large scale. It consists in precipitating the sewage by the aid of the native phosphate of alumina dissolved in sulphuric acid, and then adding caustic lime. The process was carried on at Tottenham for some time; but, owing to the difficulty experienced in obtaining the native phosphate of alumina, the scheme has failed. The effluent water was not fit to run into rivers.

3. *The "Scott Sewage Company."*—This company proposes to make a sludge by adding slaked lime to the sewage, which causes a precipitate of the carbonates, phosphates and silicates. Clay is then added to combine with the silica, and the alumina and the sludge thus formed, after being dried, is burnt into cement and lime. It takes one million gallons of sewage to produce two tons of Portland cement.

4. *The A. B. C. Process.*—The precipitating agent in this scheme is a mixture of alum, blood, clay, and charcoal; hence the name. The sewage is mixed with a given quantity of the A. B. C. mixture and allowed to settle in precipitating tanks; the clear liquid is drawn off, and the sediment is dried and sold as manure, which is of little value. The Rivers Pollution Commission makes the following remarks on this process:—

(1) The process precipitates the greater part of the solid particles of the sewage, but in no case to such an extent as to allow the superincumbent waters to run into the river.

(2) The process produces no clearer water than what would have resulted if the sewage were allowed to settle by itself.

(3) The sewage is considerably reduced in value through it.

(4) Bad smells are always perceptible.

Composition of Sewage from Sample obtained from the Southern Outfall, Crossness.

Total solid matter in solution, ...	Mineral, 67·2 Organic, 13·3	=	80·50
Total solid matter in suspension, ...	Mineral, 8·8 Organic, 10·2	=	19·00
Chlorine—chiefly as common salt, ...			21·39
Nitrogen existing as ammonia, ...			3·15
Organic nitrogen, ...			0·70

(Greville.)

A Mr Webster has recently proposed treating sewage by passing an electric current through the sewage in a tank. Gases are formed which carry the solid matters to the top. The fluid is then agitated, the gases pass off and the solid particles then settle to the bottom without any tendency to diffuse through the fluid again. This is another exemplification of the applications of electricity.

Liernur's Method.—This plan consists in drawing the excreta from the closets of a town by creating a vacuum, by means of an air-pump worked in some central station in the town. From this central station pipes radiate in all directions through the town, following the principal streets. At varying distances along these pipes, reservoirs are sunk below the pavement, which are filled directly from the house closets, and are then emptied by the continued action of the air-pump. By a system of stop-cocks, which can be turned on and off, any district may be cleared at pleasure. On reaching the central station the excreta are decanted in a fluid form in barrels, for immediate transport to the country,

by means of hermetically-closed apparatus. The closets are very simple, consisting in a double funnel, the space between the two communicating by a pipe with the external air. No water is required. The excrement falls into a sort of hydraulic trap, capable of holding the fæcal products of but one person, and compelling what is held before to fall into a larger trap of four times greater capacity, This latter discharges in the branch tube, which is connected with the main tube, and empties into the street reservoir. By a succession of short bends, repeated at regular intervals, all metal valves which are likely to get out of order are avoided, the fæcal mass practically forming the the required temporary closure from the main pipe. A separate system of sewers for rain water, street drainage, slops, and for the drainage of the soil, is necessary. This method has been adopted in some of the towns of Holland, at St Petersburg, at Prague, etc.

The advantages claimed for this method are that the pipes, which are emptied daily, are of iron, with well-made joints, and that if a hole exists in the pipe the pressure is inward and matters are "sucked in," thus closing it up. There are no valves, only cocks which are easily attended to, and the closets are without water, and ventilated from the funnel-shaped closet and also from the soil-pipe. Pipes are not liable to be stopped by improper substances thrown in them.

The following are the objections against the adoption of this method.—

1. The primary cost is great, especially as it provides for the removal of excrement alone.
2. The escape of sewer gas from the sewers, and from the plug or trap of excrement.
3. The not unfrequent overflowing of the closets, by becoming clogged with coffee-grounds, ashes, rags, etc.
4. The necessity of frequently flushing the closets, thus diluting the sewage.
5. The sewage may become frozen in winter, and therefore useless.
6. The difficulty of disposing of the sewage during winter and summer at a remunerative price.

The Influence of Drainage on Climate.

The beneficial effects of the drainage of the land apart of course from sewerage are sometimes as great as if the land had been transported 100 or 150 miles southwards (Buchan). This is due to the fact that 1 grain of water in being evaporated takes off sufficient heat to raise 960 grains, 1° F., the heat becoming latent. As in well-drained land, there is less water to evaporate, the soil becomes warmer.

WATER.

It is absolutely necessary that there should be a good supply of pure water in the neighbourhood of human habitations. Rivers, when not contaminated with sewage, are available for this purpose. In ancient Rome there were officers, "Curatores Alvei et Riparum," whose duty it was to take care of the banks of the Tiber, and to regulate its channel. The channels of rivers, it should be remembered, are always liable to deterioration from physical causes in constant action.

Important questions connected with a water supply are given in the following Table :—

1. Selection of purest available source.
2. Filtration, if necessary.
3. Storage in covered tanks for distribution by gravitation.
4. Method of collection—
   - (*a*) Mountain Ranges.
   - (*b*) Rivers and streams.
   - (*c*) Natural springs.
   - (*d*) Wells.
   - (*e*) Impounding reservoirs?
   - (*f*) Subsoil drainage (Denton).
   - (*g*) Combination of any of the above.
5. How stored ?—
   - (*a*) General. Covered reservoirs.
   - (*b*) Private. Cisterns.

6. Method of distribution—
    (*a*) Open conduits before filtration.
    (*b*) Covered conduits *after* filtration.
    (*c*) Cast-iron pipes under pressure.
7. Composition and characters.
8. Dangers to pollution—
    (*a*) At source.
    (*b*) At any point during distribution.
    (*c*) Private Storage.
9. Quantity per head.
10. Effects of water on animal economy—
    (*a*) Healthy.
    (*b*) Producing disease.

There can be no doubt that the pouring of the sewage of a town into a neighbouring stream is an unmitigated evil. Some authorites have maintained that running streams have a self-purifying power, and that organic matter is almost completely oxidised by the oxygen of the air, and by that contained in the water.

The Rivers Pollution Commission state, on the expermenents made by them with a view to the solution of this question, that "it will be safe to infer, however, from the above results that there is no river in the United Kingdom long enough to affect the destruction of sewage by oxidation."

The apparent purification of running streams is due to the following:—(1) Oxidation; (2) Deposition; and (3) Dilution.

But even with these agencies at work, it is impossible to say when a once polluted stream becomes pure and the water fit to drink. The banks of rivers, if not carefully attended to, may become the sources of disease, due to the deposit of decaying animal matter on them. The inhabitants on the banks of rivers subject to inundations are often attacked by intermittents. It may then become necessary to deepen the bed of the river, or to increase the velocity of its current by straightening its channel.

Characteristics of a Good Drinking Water.

1. It should be without taste or smell, and preferably without colour.

2. It should not contain an undue amount of solid constituents, especially when such constituents are salts of lime or magnesia. The amount of solids should not exceed eight grains per gallon, one grain of which should be alone dissipated by heat. In chalk water the solids should not be more than fourteen grains per gallon. Wanklyn, however, holds that unless a water contains more than forty grains of solids per gallon, no exception need be taken to the solids as such.

3. It should be practically free from nitrogenous organic matter, the albuminoid ammonia being less than 0·05 parts per million, and a water should be regarded with suspicion which, along with a considerable quantity of free ammonia, yields ·05 parts of albuminoid ammonia per million.

Quantity required for Individuals.—A sufficient quantity should be supplied daily to each individual. In 1852, thirty-two gallons were supplied in London daily per head, and this was increased in 1862 to fifty gallons. The daily requirement of each adult is estimated at from 70 to 100 ounces, but from 20 to 30 ounces are taken in his solid food—the rest in some form of drink.

The amount of water required for the use of animals may be estimated at eleven to sixteen gallons per day for a horse, eight to ten for a cow, and so on for other animals.

Public baths should be erected and freely supplied with water, which should, if possible, be kept constantly flowing in and out.

Table given by Professor Rankine.

	Gallons per Day per Head.		
	Least.	Greatest.	Average.
Used for domestic purposes..........	7	15	10
Washing streets, extinguishing fires, supplying fountains	3	3	3
Allowance for trade and waste	7	7	7
Total in non-manufacturing towns ..	17	25	20
Additional demand in manufacturing towns	10	10	10
Total in manufacturing towns	27	35	30

Parkes maintained that for personal and domestic use without baths, twelve gallons should be the minimum daily supply ; with baths, sixteens gallons, not including water-closets, which require four to six gallons per head. Taken altogether, provision should always be made for a daily minimum supply of twenty-five gallons per head, with an additionl allowance of three gallons for unavoidable waste. For hospitals, from thirty-eight to fifty gallons should be allowed.

Table giving the General Powers and Duties of an Urban Authority under Public Health Act, 1875, with regard to Water Supply.

POWERS.	DUTIES.
General powers for supplying district with water, viz., to construct waterworks, dig wells, lease, hire, or purchase waterworks, and to contract to supply water; to carry mains within and without district; to supply water by measure; to supply water to adjoining district; to close polluted wells; to borrow money to carry out any of the above.	To keep waterworks in good order and repair, and to supply pure and wholesome water; in some cases to require houses to be supplied with water; to supply water when required for public baths and for trading purposes; to provide fire plugs; to prosecute persons polluting the water. *Note.*—Individuals may object if they are affected by the construction of waterworks.

Local Authority cannot supply water if there is a good supply from existing Company to district.

Storage of Water.—The provision to be made for storage will depend upon the consumption, calculated at so much per day for each individual of the estimated population of the district. In London, for instance, the water supplied by the New River Company is taken from the New River and the Lea, and a few ponds. The water is first collected in a large reservoir, and then passed into the filters, which are brick tanks open to the air, the bottoms of which are covered with four or five feet of sand and coarse gravel in the following order, beginning from the bottom :—A layer of bricks, six inches deep, then six inches of gravel; and, lastly, a layer of sand, two feet six inches deep—on the surface of the sand, the water is five feet deep. This arrangement allows of a filtration of 4·5 cubic feet per hour. It has been found that the active portion of the filter is about half-an-inch in depth of the upper layer of sand, and this has to be removed, in some cases, every two months, washed with water, then re-laid, and again used. Through this bed of sand and gravel, the water has to percolate before it reaches the filtered water reservoir, whence it is pumped to the reservoirs of the Company, placed on the highest parts of the neighbourhoods supplied by the New River system. After filtration, the water should be kept in covered reservoirs to protect it from the sun and from contamination. The rate of filtration should not exceed 700 gallons per square yard of filter bed in twenty-four hours. For the domestic purification of waters small filters are used. These act in two ways, mechanically and chemically. Thus *mechanical* action consists in removing all suspended impurities, the *chemical* in oxidising deleterious organic products. The best materials for this purpose are animal charcoal and magnetic carbide of iron, prepared by roasting a mixture of hematite with saw dust. Many other materials have been proposed, "spongy iron," *carferal,* a mixture of charcoal, iron, and clay, but Professor Frankland is so strongly in favour of animal

charcoal, that in spite of its great cost, he would employ it on a large scale for the purification of town supplies. The worst possible material for filters is sponge.

The points in a good filter are—(1) Easy access to the filtering material. (2) Perfect cleanliness. (3) Frequent changing or purification of the filter.

Charcoal filters may be purified by frequently brushing their surface, boiling in hydrochloric acid and then passing through them a solution of permanganate of potash.

Private Storage.—For the private storage of the inhabitants—slate, lead, iron, and zinc cisterns are used. The first are the best, but cisterns of zinc are most used, on account of the cheapness of the material. Lead is open to the objection of the poisonous nature of the soluble compounds sometimes formed by the action of the water on the metal. Slate cisterns are difficult to keep watertight; and if iron ones are used, they should be coated with the patent material used for water-mains. All cisterns should be kept covered to prevent contamination, but free ventilation should be provided. They should also be placed so as not to damage the house or render it damp in case of leakage, and also be easy of access for inspection, cleaning, etc. Care must be taken that the waste does not communicate with the drains or closet-trap, but that it opens into the open air. A common practice in London is to carry the waste pipe into the closet-trap. All cisterns should be inspected and cleaned periodically.

In their report on the storage of water in houses, the Rivers Pollution Commissioners remark :—

"All storage of drinking water in houses is attended with the risk of pollution. Good water is spoiled, and bad water rendered worse by the intermittent system of supply. All drinking water ought to be drawn direct from the main. Under proper supervision, the waste of water is less on the constant than it is on the intermittent system of supply. These and other advantages have led to the adoption of the constant system in a great majority of British towns."

Birmingham, Wigan, and Eastbourne, are supplied with water on the constant system; Bath, Tunbridge Wells, and Oxford, on the intermittent.

The objections to the constant supply system are that it encourages waste and extravagance, and that no means can be taken to provide against these. These objections are only valid when the taps and fittings used under the intermittent system are allowed to remain. When the constant system is adopted, only "screw-down taps" of the best description should be allowed; and to prevent waste from closets, a small cistern may be connected with each closet, containing one gallon—enough water for one "flush." It has also been suggested to put the service pipes in the poorer neighbourhood of a town in such a position on the landings that neglect shall cause such inconvenience as to enforce care.

Various Sources of Water Supply.

1. *Rain Water.*—This ranks next in purity to distilled water, but may become contaminated by passage through the air. As a supply to large towns, it must not be trusted, for the following reasons:—

(1) Uncertainty of supply. To estimate the rainfall as a source of supply, take the rainfall of the three consecutive driest years.

(2) The quantity falling in an inhabited country is small in proportion to the number of the inhabitants.

(3) Not very palatable to the taste.

(4) Expense in collecting, and liable to become contaminated by storage.

(5) In manufacturing towns, rain water may contain sulphuric acid, and also be more or less impregnated with soot.

If used by small communities, rain water should not be allowed to remain in lead, but in slate cisterns of small size, or in tanks sunk deep in the ground to prevent evaporation, and it should be collected as pure as possible. Gibraltar, Venice, and Constantinople are so supplied.

To find the amount of rain water that can be collected from any roof, reduce the area to square inches, multiply by the rainfall, and the result by ·003607 to find the number of gallons supplied, or by ·00058 for cubic feet. One inch of rain gives 4·673 gallons for every square yard, or 22,617 for each square acre, or 4840 square yards; hence, given rainfall in inches and number of inhabitants, calculate extent of "catch" ground required to supply fifty gallons daily per individual. (See "Useful Formulæ," page 564, *et seq.*)

2. *Snow Water.*—Not pleasant to the taste, and is said to cause gastric derangement.

In Moscow, cholera has occurred in the winter owing to the inhabitants throwing the choleraic dejections on the snow round their houses, and then melting it for domestic purposes. Water from melted snow is largely used by the farmers of Manitoba.

3. *Spring and Well Water.*—Water from these sources varies greatly in composition.

(1) Always much harder than lake or river water.

(2) Superficial wells apt to contain organic matter from churchyards, cesspools, etc., and also salts, sulphates, and carbonates of lime—the latter kept in solution by excess of carbonic acid. By an improved system of sub-soil drainage, the waters from these wells may be rendered pure and wholesome.

(3) Deep wells contain much lime, sometimes as much as $1\frac{1}{4}$ tons of chalk per 1,000,000. Deep wells, however, from an engineer's point of view, are perhaps the best source of drinking water, but they are open to several objections:—(1) Cost of sinking. (2) Drying up other wells in their vicinity. (3) Insufficiency of the supply. (4) Expense of raising water from great depths. (5) After great expense in sinking no water may be obtained, or if found, it may be salt or brackish. The sinking of the

Dudley Lane well by the Corporation of Liverpool ended in drying up the other wells, which were then used as cesspools, with subsequent percolation of sewage into the Dudley Lane well.

(4) Artesian wells may contain large quantities of the alkaline carbonates and sulphate of lime.

An Artesian Well—from Artois in France—is a deep well bored through impervious strata to a water-bearing stratum in which the water is under such a pressure as to cause it to rise to the surface. The Artesian well at Grenelle drains a district above 100 miles distant from Paris. These wells have been used in China from remote antiquity.

Sometimes a spring may appear on the side of a hill owing to a "fault" in the water-bearing strata. The "American," "Abyssinian," or "tube wells" are made by driving a cast-iron tube about two inches in diameter into the ground. The tubes are in short lengths, screw into each other, and then driven down till water is found. These wells are useful in supplying water to an army. They, however, failed in the Ashantee War, from their becoming clogged with sand.

4. *River Water* may contain organic matter from sewage, and also impurities from the soil, etc. As a rule, river water is very pure.

5. *Lake Water* is also a pure water. Glasgow is supplied from Loch Katrine, which is probably the purest known natural water, containing only about $2\frac{1}{2}$ grains of solid matter per gallon.

6. *Marsh Water* is most impure.

7. *Peaty Water* is not injurious, though unpleasant to the taste.

Impounding Reservoirs are formed by throwing a dam across a valley through which a stream flows, and thus forming an artificial lake. Edinburgh is largely supplied by water from an impounding reservoir in the Moorfoot hills, from which the water is brought by gravitation to the town.

To calculate the Time employed in filling and emptying a Reservoir when the Supply and Consumption are going on simultaneously:—

Q = supply of water to reservoir in cubic feet per minute.

q = consumption of water from reservoir in cubic feet per minute.

C = contents of reservoir in cubic feet.

T = time required for filling reservoir in minutes.

t = time required for emptying reservoir in minutes.

$$T = \frac{C}{Q - q} \qquad t = \frac{C}{q - Q}$$

1. The quantities of a fluid discharged in equal times by the same apertures, from the same head, are nearly as the areas of the apertures.

2. The quantities of a fluid discharged in equal times by the same apertures, under different heads, are nearly the square roots of the corresponding heights of the fluid above the surface of the apertures.

3. The discharge of fluid through a cylindrical horizontal tube, the diameter and length of which are equal to one another, is the same as through a simple aperture.

4. If the horizontal tube be of greater length than the diameter, the discharge of fluid is much increased, and may be increased with advantage up to a length of tube four times the diameter of the aperture.

To find the Pressure of Fluid on the Bottom of its Containing Vessel.—Multiply area of base by height of fluid in feet, and the product by the weight of a cubic foot of the fluid.

To Compute the Pressure of a Fluid upon a Vertical, Inclined, Curved, or any Surface.—Multiply the area of the surface by the height of the centre of gravity of the fluid in feet, and the product by the weight of a cubic foot of the fluid.

Give the pressure on a sloping side of a pond of fresh water 10 feet square, the depth being 8 feet.

Centre of gravity, $8 \div 2 = 4$.

Then $10^2 \times 4 = 400 \times 62{\cdot}5 = 25{,}000$ lbs.

Required the direction and magnitude of the pressure against a flat circular valve inclined to the horizon at an angle of 45°, and employed to retain fresh water in a reservoir; the centre of the valve is sixteen feet below the surface of the water, and the diameter of the valve one foot.

The direction of the pressure is at right angles to the valve.

The area of valve $= 12 \times 12 = 144 \times {\cdot}7854 = 113{\cdot}09$.

Pressure of water per sq. inch at 16 feet is ${\cdot}4332 \times 16 = 6{\cdot}9312$ lbs.

Therefore, the pressure on the valve is $6{\cdot}9312 \times 113{\cdot}09 = 783{\cdot}849$ lbs., the total pressure on the valve.

One cubic inch of water $= {\cdot}0361$ lbs., $\therefore$ ${\cdot}0361 \times 12 = {\cdot}4332$ lbs.

Area of valve $= D^2 \times {\cdot}7854$. D = diameter.

Table showing the Relation between the General Character of a Water, and the Geological Strata from which it is derived.

Alluvial—	Generally more or less impure, and exceedingly variable in quality and in constituents.
Chalk—	Clear, wholesome, and sparkling; generally very pure, and chiefly characterised by the solid matter consisting almost entirely of carbonate of lime.
Limestone and Dolomite—	Wholesome and agreeable, but characterised by a larger amount of total solid matter than chalk water, and the presence of a greater quantity of the sulphates of lime and magnesia.
Millstone, Grit, and Hard Oolite—	Generally very pure; the solid constituents small, and consisting chiefly of the sulphates and carbonates of lime and magnesia, with a little iron.
Soft Sandstone Rock, Loose Sand and Gravel, and Lias Clays—	Very variable in quality—no average criterion can be given.
Granite, Metamorphic, Trap Rock, and Clay Slate Formations—	Generally very pure; small quantities of solid constituents, mainly carbonate of soda and chloride of sodium, with a little lime and magnesia.

The following is the classification of waters given in the Rivers Pollution Commission's sixth report:—

Wholesome	Spring. Deep well water. Upland surface water—*i.e.*, uncultivated and unmanured land, as hills and mountains.
Suspicious	Stored rain water. Surface water from cultivated land.
Dangerous	River water containing sewage. Shallow well water.

Hard and Soft Water. — Natural waters contain varying proportions of lime and other mineral salts, and on the amount of these constituents depends the relative *hardness* or *softness* of water. The hardness of water is mainly due to the presence of the salts of lime and magnesia. When these are present in excessive

quantity, the water is said to be "hard;" and when heated, incrustations are formed on the inside of vessels. A great destruction of soap also occurs when such water is used for washing clothes and other purposes. A "soft water" is one below six degrees of hardness, and "each degree of hardness destroys $2\frac{1}{2}$ ounces of soap in each 100 gallons of water used for washing. Soft water is commercially of more value than hard water in proportion to the worth of 5 ounces of soap to each 200 gallons for each degree of hardness." In brewing, however, hard water is an advantage, and the permanent hardness due to sulphate of lime may even reach to 28 or 30 degrees without detriment to the water.

Degree of Hardness.—By this term we mean that a given volume of water decomposes a certain number of C.C. of the standard soap test. Thus, "fifteen degrees of hardness" means that fifteen C.C. of the soap solution have been used. Each C.C. = one degree of hardness.

In Clark's estimation of "hardness" each degree of hardness corresponds to one grain of soap-destroying salts in a gallon of water, and does not refer to the quantity of soap which a gallon of the water will destroy.

A *rough* means of judging of the relative degree of hardness of any sample of water consists in placing a small quantity in a test-glass, and adding to it a few drops of a standard solution of soap in alcohol, when a white turbidity will make its appearance, depending in degree on the hardness of the water.

Some hard waters are softened by boiling; others are not. The hardness of water removed on boiling is due mainly to the presence of the *carbonates of lime and magnesia;* whilst the water, the hardness of which is but slightly, if at all, affected, contains *sulphate of lime.* Chalk waters are most influenced by boiling, as the carbonate of lime is held in solution by the

excess of carbonic acid present. When a chalk water is boiled, the carbonic acid is expelled, and the carbonate of lime is to a great extent precipitated. The hardness, due to carbonate of lime, is termed "temporary," as it can be thus removed; that due to the sulphates of lime and magnesia, is termed "permanent," as it is not removable by boiling. It is always desirable to know to which of the above the "hardness of water" is due, as, in excessive cases, a knowledge of the cause would determine whether the water might be rendered fit for domestic purposes.

In order to estimate the exact degree of hardness in any given sample of water, accurate standard solutions are needed. These are prepared as follow:—As a basis, a solution of lime is made by dissolving 0·2 gramme (3·088 grs.) of Iceland spar in dilute hydrochloric acid, evaporating to get rid of the free acid, and finally dissolving the calcic chloride in distilled water, and diluting to one litre. A solution is then made by rubbing together in a mortar 150 parts of lead plaster (Emplast. Plumbi) with 40 parts of dry potassium carbonate. The mixture is then treated with methylated alcohol, thrown into a filter, and washed several times with fresh portions of methylated spirit. The solution thus obtained is diluted with a mixture of one volume of distilled water and two volumes of methylated alcohol, until exactly 14·25 cubic centimetres (220 grs.) are required to form a permanent lather with 50 C.C. (772 grs.) of the standard calcic chloride solution.

This soap solution is used for taking the degree of hardness in a water as follows:—50 C.C. of the water are placed in an eight-ounce stoppered bottle, shaken briskly for a few seconds, and the air then sucked out (to remove carbonic acid). The standard soap solution is then run in in small quantities at a time, shaking the bottle after each addition, until a lather is formed permanent all over the surface of the water for five minutes. By noting how much soap solution has been

used, and referring to a table, the degree of hardness is determined. Each "degree" represents a hardness equal to one grain of carbonate or sulphate of lime per gallon in soap-destroying power.

When waters have a hardness of more than sixteen degrees, the water must be diluted with distilled water before making an estimation.—(See "Wanklyn and Chapman's Water Analysis.")

Nature and Origin of Deposits in Boilers.

When water containing a quantity of earthy salts is concentrated, not only is the carbonate of lime deposited in the way just described, but as the solution becomes more and more concentrated, the other earthy constituents present are more or less completely thrown down. Thus, we find that a large deposit occurs in steam boilers in which ordinary water is used, and much inconvenience frequently arises from this source, especially when the deposit assumes a compact form, from the slowness of its deposition. The bursting of boilers may often be due to this deposit. Water boils more readily in a vessel with rough sides than in one in which the sides are smooth and polished, and in these rugosities a large quantity of air is confined. The sudden expansion of the contained air, and rapid vaporisation of the water, often causes a bursting of the boiler before the temperature has reached the boiling point. The accidents due to this cause often occur before the machine has begun to work, and when the manometer shows a pressure but a little above that of the atmosphere. Sometimes a crack may occur in the incrustation, allowing the water to come in contact with the almost red-hot iron of the boiler. A sudden formation of steam results, which may destroy the boiler. Many schemes, both chemical and mechanical, have been proposed to prevent the deposit in boilers; but the treatment must vary with the character of the water. If the incrustation cannot

by any means be *prevented*, a plan frequently adopted is to introduce some light powdered substance into the boiler with the water. This acts mechanically by keeping up the free generation of steam; and the water being thus kept in constant and violent motion, the earthy salts are precipitated in the form of a fine powder, which is periodically removed by "blowing out," as it is termed. The chemical scheme which appeared most likely to prove successful, consisted in the addition of chloride of ammonium to the water in the boiler. A conversion of the carbonates of lime and magnesia into soluble chlorides is the result, while the carbonic acid passes off with the ammonia as carbonate in the steam. The great objection to this method is, that carbonate of ammonia acts on brass or copper fittings, and this has precluded the employment of the process, except under special conditions.

There is a process, known as *Clark's Process*, in use for the prevention of boiler deposits, and for the softening of water for domestic purposes. This process is, however, only adapted to the treatment of chalk waters to get rid of the "temporary hardness," and for these it is exceedingly useful. It is carried out in the following manner:—The water, collected in large tanks, is treated with a sufficiency of lime water to neutralise the free carbonic acid present. As the carbonate of lime present in the original water is only retained in solution by the excess of carbonic acid, it follows that, if this be removed, the carbonate of lime will be precipitated. The lime water acts, therefore, by neutralising the carbonic acid, forming with it insoluble carbonate of lime, which is thus precipitated together with the carbonate of lime previously dissolved in the water. By this means, not only is the lime almost entirely removed, but a certain degree of organic purification takes place by the precipitated lime carrying down with it a considerable amount of the organic matter present.

The above process is now in use on a large scale at several paper mills, and at other manufactories. It can also be carried out in private houses. The Kent Companies' water, the purest of the London supplies, obtained from deep wells in the chalk, was formerly entirely treated by Clark's process before it was supplied to the public. One cwt. of lime costing eightpence, will do as much in softening the water as a ton of soap, costing £47 : 1 : 8, or of $4\frac{3}{4}$ cwts. of sodium carbonate at £2 : 17 : 9.

The following objections have been raised against the process :—

1. That the softened water attacks lead—denied by Wanklyn.

2. That the process is not applicable to waters containing organic matter in large quantity, because the chalk precipitated will not subside—answered by condemning all waters with a *large* quantity of *organic* matter.

3. That as, in carrying out the process on a large scale, great volumes of the water must be left at rest for many hours, extra reservoirs would be required, and the expense of water-works thereby greatly increased.

4. That the quantity of chalk which would accumulate at the bottom of the reservoirs would require frequent removal and entail expense.

The two last objections can only be answered by comparing the relative cost of other proposed schemes. (From Wanklyn.)

Origin of the Sulphuretted Hydrogen of Sulphurous Waters.

The presence of sulphuretted hydrogen in water is generally held to arise from the deoxidising influence of decaying organic matter on the various sulphates present ; the oxygen of the sulphuric acid unites with the carbon of the organic matter to form carbonic acid, while the sulphur combines with the hydrogen to form sulphuretted hydrogen.

Action of Hard and Soft Waters on Lead.

Natural waters are found to act in a variety of ways on lead; and as drinking water generally meets with lead either during its conveyance from the Company to the consumer through pipes of that metal, or by being stored in leaden cisterns, it becomes of the utmost importance that the conditions under which natural waters become charged with lead should be known. There is one broad fact which may be taken in connection with this subject, that hard waters have, as a rule, very little, if any, action on lead; while soft waters invariably dissolve more or less of that metal. The impunity with which hard waters may be stored in leaden cisterns depends on the fact that a coating of insoluble lead salts is soon formed on the surface of the metal, which protects the lead from the further action of the water. The salt having the most protective action is the sulphate; and as ordinary hard waters, as a rule, contain earthy sulphates, we are able to use such waters with impunity. On the other hand, as soft waters have no such protective properties, they become more or less charged with lead; the oxygen dissolved in the water forming oxide of lead, which, soluble in the water, causes contamination. Waters containing nitrates or nitrites in solution are especially to be avoided, as such waters exercise a powerfully solvent action on lead; and these salts have been known to corrode that metal to such an extent as to eat holes in the cistern in which the water was stored.

Lead is a metal which fortunately admits of easy detection, even when in minute quantities. If present to any extent, it can be detected by taking a portion of the water in a tall glass jar and adding some sulphuretted hydrogen water, when, if lead be present, a brown colour is observable, which may be rendered more apparent if the jar containing the water be held over a piece of clean

white paper. When present in minute quantities, and more especially if it be desired to make a quantitative estimation of the amount present, some of the water should be evaporated to a small bulk, and then acidified with hydrochloric acid. On the addition of sulphuretted hydrogen water, the whole of the lead will be thrown down as the sulphide.

If a solution containing a known quantity of a salt of lead be treated with sulphuretted hydrogen, and the colour so produced compared with that of the suspected water, to which sulphuretted hydrogen, has also been added, a quantitative estimate of the lead present may be made.

Practical Test of the Action of Water on Lead.—Take a beaker containing eight ounces of the water to be examined, and place in it a piece of plumbers' cistern "six-pound lead," four inches by one inch. Each square inch of the lead sheet is thus acted upon by one ounce of water. The water may be examined daily, the colour produced on the addition of sulphuretted hydrogen compared with a standard solution of lead. Wanklyn gives the following process:—Take 70 C.C. of the water, place them in a white porcelain dish, and stir with a glass rod dipped in sulphide of ammonium. If the slight colouration formed be not absolutely destroyed on acidification with hydrochloric acid, the water should be condemned as contaminated with metallic impurity —either copper or lead. Lead poisoning may result from so small a quantity as one-ninth of a grain per gallon.

Different Forms under which Nitrogen is found in Water.

Nitrogen is found in water under the following forms:—(*a*) Ammonia. (*b*) As Nitrates and Nitrites. (*c*) As Nitrogenous Organic Matter.

Nitrogen under one or other of the above forms is found in small quantities in all waters. Some of the chalk waters invariably contain nitrates and nitrites, probably due to fossil organic remains. The sources whence the nitrogen in water is derived vary. Rain water, especially when collected near towns, invariably contains small quantities of nitrogen in the form of ammonia, dissolved during the passage of the rain through the air.

The sources of nitrogenous organic impurities are chiefly of animal origin, due to infiltration from cess-pools and churchyards.

Although the mere presence of nitrates and nitrites in a drinking water cannot be looked upon as affording conclusive proof of a "previous sewage contamination," it should always be regarded as a suspicious circumstance, and should lead to a search for possible sources of contamination. (Corfield.)

Estimation of Nitrates and Nitrites.

(Wanklyn and Chapman's Method.)

This is a modification of Shultze's aluminium process, and is an exceedingly accurate test. About a pint of the water to be tested is placed in a retort, and a definite quantity of strong, pure caustic soda solution added, and the whole distilled till all the ammonia has been driven off. The contents of the retort are now left to cool, and a piece of thin sheet aluminium introduced, and allowed to remain for four or five hours. Hydrogen is evolved from the metallic aluminium, which, being in the nascent state, unites with the nitrogen of the nitrates and nitrites present to form ammonia. After the action has ceased, the contents of the retort are again distilled, and the ammonia given off estimated by Nessler's test. The ammonia thus obtained is an index of the amount of the nitrates and nitrites present.

The Nessler Test.

This reagent is prepared by dissolving 50 grammes (772·0 grains) of potassium iodide in a small quantity of distilled water, subsequently adding a cold saturated solution of corrosive sublimate until the precipitate of mercuric iodide ceases to be dissolved. 200 grammes (3088 grains) of caustic potash in strong aqueous solution is then added to the above, and the whole made up by the addition of water to one litre. A little more of the corrosive sublimate is then added, and the whole allowed to settle. The clear liquid is then decanted and preserved in closely stoppered bottles in a dark, cool place, until required for use. The addition of the last quantity of corrosive sublimate solution is requisite in order to impart the necessary sensitiveness to the test.

The Nessler test is based on the fact that, when a saturated solution of iodide of mercury in iodide of potassium, rendered strongly alkaline by the addition of caustic potash, is added to water containing ammonia, various shades of a brown colour are produced. By comparing these shades of colour with those produced in standard solutions of ammonia, the amount of ammonia present in the sample of water under examination may be estimated. It is necessary that the ammonia solution be very dilute; for, if too strong the reagent will be either precipitated, or the delicate shades of colour, so necessary for the success of the test, destroyed by the intense dark colour produced. In testing ordinary water, it is necessary to concentrate the water by distillation; but in the case of sewage, which is always rich in that substance, pure distilled water, free from ammonia, must be added to the distillate till the proper degree of dilution is obtained. In this process all apparatus used must be scrupulously free from ammonia.

Quantitative Examination of Potable Water.

The ordinary quantitative examination of water involves the estimation of the following points:—Total solid matter, hardness (temporary and permanent), chlorine, ready-formed ammonia, nitrogen existing in organic matter, or "albuminoid ammonia," and nitrogen in the form of nitrates and nitrites.

Determination of the Total Solid Matter.—For this purpose a measured quantity of the water is evaporated on the water bath in a platinum basin to dryness, and the weight of the perfectly dry residue then ascertained. It is best to ascertain the exact weight of the perfectly clean platinum basin, to then introduce the water to be evaporated, and, after the evaporation, to transfer the basin and its contents to an air-bath heated to about 250° F., by which the water residue is thoroughly dried. The basin may then be withdrawn from the air-bath, rapidly cooled by being placed on a massive piece of iron, and weighed. The increase in weight above that of the platinum basin will give the solid matter. It is advisable to replace the basin containing the water residue in the air bath for a short time after the first weighing, and to subsequently re-weigh, in order to be perfectly sure of the absolute dryness of the residue. Any quantity of water may be taken for evaporation, but it is not advisable to employ too large a quantity, as the time occupied is considerably increased, and there is more danger of error from the settlement of dust. About 2000 grains is a convenient quantity, if the operator is in possession of an accurate balance, the above quantity being $\frac{1}{35}$ of a gallon. If 3500 grains be taken, the result is multiplied by 20, this quantity being $\frac{1}{20}$ of a gallon. After weighing the perfectly dry water residue, the contents of the platinum basin may be gently ignited, and any blackening noticed as an indication of the presence of organic matter; the smell evolved at the same time will afford a rough

criterion as to whether the organic matter is of animal or of vegetable origin. The actual amount of the "loss on ignition" may be noted, but is not of much distinctive value.

Examination of the Water Residue.—The unignited residue is best employed for this purpose. A small quantity of distilled water is placed in the basin, and the reaction of the liquid to red litmus paper noticed, when an alkaline reaction will betray the presence of alkalies (potash or soda generally as carbonate). A few drops of hydrochloric acid are then added, when any effervescence indicates the presence of carbonates. The liquid may then be tried for sulphates, for lime, and for magnesia in the usual way.

Determination of Chlorine.—This is generally performed volumetrically by means of a standard solution of silver nitrate, using potassium chromate as an indicator. The method is founded on the affinity which silver possesses for chlorine over that which it has for chromic acid, and on the distinctive colours of the compound formed in each case. In using the process, the silver nitrate solution is dropped into a measured quantity of the water, tinted a faint yellow by the previous addition of a few drops of a solution of potassium chromate. As long as any chlorides are present in the water, white silver chloride is formed, but the moment the amount of soluble chlorides is exhausted the liquid acquires a reddish tint from the formation of red silver chromate.

The standard solution of silver nitrate is prepared by dissolving 4·79 grammes of the pure salt in one litre of distilled water. One cubic centimetre of this solution equals one milligramme of chlorine, or every grain measure equals ·001 grain chlorine.

The water should be placed in a white porcelain basin during the examination, and the condition for accuracy is that the water must be neutral, or faintly alkaline.

Nitrogen in the Form of Ammonia, and as Nitrogenous Organic Matter.—For the purpose of estimating the amount of nitrogen in the above-mentioned forms, the method of Wanklyn and Chapman is that generally adopted. The process is dependent on the use of the Nessler test in the estimation of ammonia, and on the fact that nitrogenous organic matter yields a definite quantity of its nitrogen, in the form of ammonia, on distillation with an alkaline solution of potassium permanganate.

The following are the methods for the estimation of the Free Ammonia and "Albuminoid Ammonia:"—

1. Free Ammonia.—A pint of the water to be examined is placed in a scrupulously clean, stoppered glass retort, connected with a Liebig's condenser. A small quantity of a saturated solution of carbonate of soda is added to the contents of the retort, and the whole carefully distilled. The distillation is continued until 150 C.C. have passed over, and are collected in three successive pure white glass tubes, an inch and a quarter in diameter, and at least a foot long, each holding 50 C.C. of the distillate which contains the ready-formed ammonia present in the water. A measured quantity (2 C.C.) of Nessler reagent is added to the contents of each tube, and the colour produced imitated by adding the reagent to a standard solution of ammonia in a similar glass tube. Several trials are made till the shade of colour in both cylinders is alike, when the amount of standard ammonia used will give the quantity of this substance in the suspected water. The standard ammonia solution is made by dissolving 0·0315 grammes (0·48636 grains) of ammonia chloride in a litre of water. Each C.C. of the solution contains ·0001 grammes of ammonia, or each grain measure equals ·0001 grains.

2. "Albuminoid Ammonia."—A certain proportion of a strongly alkaline solution of permanganate of potash, of known strength, is now added to the contents of the retort, and the process of distillation resumed. The distillation is stopped as soon as the last portions of the distillate cease to give the reactions of ammonia. The distillate contains all the ammonia, which may now be tested as before. The quantity so obtained is a measure of the amount of nitrogenous organic matter present in the original water.

The alkaline solution of potassium permanganate is made by dissolving 8 grammes (123·5 grains) of the permanganate and 200 grammes (3088 grains) of potash

in a litre of water. The quantity of the solution used is about a tenth part of the water originally taken for analysis. The ammonia is estimated by Nessler in the manner already described.

Gases Dissolved in Water and their Estimation.

The gases are oxygen, nitrogen, carbonic acid, sulphuretted hydrogen, and in marsh water, marsh gas. The first three may be estimated by using a mercurial trough with a graduated glass tube filled with mercury and inverted in the trough. The water is then gently boiled in a flask for an hour, and the gases passed into the tube. With the aid of a pipette a solution of caustic potash is passed up the tube to absorb CO_2. When no further decrease of volume, read off CO_2. Then in the same way pass up a solution of pyrogallic acid to absorb O, and read off volume. Nitrogen alone now remains, and its volume read. Sulphuretted hydrogen may be detected by its smell or the addition of a solution of acetate of lead. In the above process the CO_2 is increased, due to decomposition by heat of the carbonates, and the O and N cannot all be obtained by this method.

Frankland and Armstrong's Method.

Frankland and Armstrong's process consists in submitting to organic analysis, by combustion with oxide of copper in a combustion tube, the residue obtained by evaporating the water under examination to dryness. The gases—nitrogen and carbonic acid—liberated during the combustion are collected in a graduated tube. The carbonic acid is withdrawn by the aid of caustic potash, leaving the nitrogen, when its volume can be read off. Previous to evaporation any nitrates or nitrites are destroyed by the addition of sulphurous acid to the water. The above process gives the amount of nitrogen present in the form of ammonia and organic nitrogenous matter.

The amount of nitrogen present as nitrates and nitrites is estimated by treating the residue of another portion of the water with strong sulphuric acid in a graduated tube standing over mercury. On agitating the tube, the whole of the nitrogen present in the form of nitrates and nitrites is liberated as nitric oxide, the volume of which is read off and halved for the amount of nitrogen. As the evolution of hydrochloric acid gas, the result of the action of the sulphuric acid on any chloride present, would interfere with the result, all the chlorides are destroyed by the addition of sulphate of silver previous to the addition of the sulphuric acid.

The Collection of Samples.

Rules with regard to the collection of samples of water—

1. Collect sample in a scrupulously clean glass-stoppered "Winchester quart," which holds about half a gallon. Tie stopper down with a piece of clean calico or linen.

2. Keep water in a cool, dark place, and, if possible, proceed to its examination within forty-eight hours after collection.

3. In collecting samples of town water, draw direct from street mains or at jets at cab-stands, first allowing some of the water to run away, so as to clean the pipe.

4. In collecting from a pond or river, be careful not to allow any surface scum to enter. Immerse the stoppered bottle, and then remove the stopper. Collect water in the middle of a stream, in the case of a river. Avoid outlets of sewers and feeders.

5. Make a note of localities of collection, late rains, or droughts.

6. Rinse out bottle with some of the water to be examined, and do not quite fill it.

Qualitative Examination of Water.

In many cases, a qualitative examination of a specimen of water will afford a sufficient criterion of its suitability for domestic purposes; in any case, however, where the character of the sample is doubtful, a quantitative examination should be made.

The following Table will afford the necessary information as to the method of conducting a preliminary examination of any specimen of water:—

Table for the Qualitative Examination of Water.

Hardness	To a small quantity of the water in a large test tube add a little "Soap test," and shake, when the degree of turbidity produced will afford a rough indication of the degree of hardness.
Chlorine	Acidify a little of the water with nitric acid, and add a few drops of silver nitrate solution. Four grains of sodium chloride per gallon gives a slight turbidity, ten grains a slight precipitate, and twenty grains a considerable precipitate.
Organic Matter, or recent sewage contamination..	Add to a few ounces of the water sufficient dilute solution of potassium permanganate to produce a faint pink colour. The solution will gradually become decolourised, the rapidity depending on the amount and characters of the organic matter present. Ferrous salts, nitrites, and H_2S must be absent.
Sulphates.........	Acidify with hydrochloric acid, and add a few drops of barium chloride solution—a white turbidity will be produced, varying in amount with the quantity of sulphates present.
Free Ammonia.	Add a few drops of Nessler test, and note the degree of brown or yellowish colouration produced.
Nitrates..........	Mix a little of the water with twice its bulk of pure sulphuric acid, then add a drop of a solution of pyrogallic acid. A pink-blue colour, changing to brown, indicates nitrates.
Nitrites	Acidify water with sulphuric acid, and add a little *pure* potassium iodide, followed by a little freshly-prepared starch solution. A blue tint indicates the presence of nitrites.
Lead, Copper, or Iron.	Acidify some of the water with hydrochloric acid, and add a little sulphuretted hydrogen water. Any brown colouration indicates lead or copper. Or the water may be stirred with a glass rod dipped in ammonium sulphide, and colour noticed. Iron gives the same colouration, but the colour disappears on the addition of HCl.

Interpretation of Results.

Hardness.—An excessive amount is undesirable.

Chlorine.—Good drinking water should contain very little chlorine unless the presence of it be explained by the geological character of the formation from which the water is derived, or the proximity of the source of supply to the sea. Chlorine in abnormal quantity (except under the circumstances named) may indicate sewage contamination; and, if associated with organic matter and free ammonia, the contamination is *recent*, and may be dangerous—if with nitrates and nitrites, the danger is less.

Organic Matter.—This should not be present in any quantity, and, except where obviously of vegetable origin, as in the case of peaty waters, should be regarded with suspicion—more especially if associated with chlorine and free ammonia in abnormal quantity.

Nitrates and Nitrites.—These should be regarded with suspicion, except in the case of deep well waters and those derived from the chalk. In shallow well waters the presence of nitrates and nitrites is invariably to be regarded with distrust, as proving an existing contamination which may be liable to assume a dangerous character. In this case chlorides will also be found. The presence of nitrites point to a more recent contamination than the presence of nitrates. Nitrates are harmless in themselves but their presence points to possible danger.

Sulphates.—If unassociated with any special geological features which would account for the presence of an unusually large amount of sulphates, their existence in excessive quantity, taken in conjunction with chlorides, organic matter, ammonia, etc., is corroborative evidence of sewage contamination.

Ready-formed Ammonia.—A water containing any recognisable amount of this substance is always to be regarded with suspicion. Corroborative evidence is obtained from the simultaneous presence of organic matter and chlorides.

Diseases due to Impure Water.

Diarrhœa.—Due probably to the presence of organic matter, chiefly of animal origin. Suspended fine mica scales have also been accredited with the production of this disease.

Dyspepsia, or more properly, certain gastric symptoms to which the popular term dyspepsia is applied, are said to be caused by the use of hard water.

Dysentery.—Several epidemics of this disease have been traced to the use of impure water, especially when impregnated with sewage.

Diphtheria, Scarlet Fever, Ague, and other Malarious Fevers.

Entozoa, etc., may be conveyed by water. Tape-worm ova, the ova of distoma hepaticum, etc. The filaria sanguinis hominis, bilharzia hæmatobia, etc.

Miasmatic Contagious Diseases.

Typhoid fever has been clearly traced to the use of impure water; and the researches of Dr Snow and Mr John Marshall have proved that cholera is spread by contaminated water. It is always advisable therefore to examine the condition of the water at the commencement of a sudden outbreak of either of these diseases.

FOOD.

The requirements of the economy that food has to meet are those which constitute the physiological phenomena of the life of animals—the development of heat, which the body requires for its maintenance, and also the production of nervous and muscular power. Food, therefore, contains the potential energy which, by processes acting within the body, is converted into actual energy—the sum of which we call life.

The potential energy of meat-food is greater than the energy it develops, because thorough oxidation of all the albumen can never occur, for some of the constituents of the albumen always pass out incompletely oxidised in the form of urea. The potential and the actual energy of sugar are, however, practically the same ; for it is, as a rule, perfectly oxidised in the body, passing off as carbonic acid and water. Professor Frankland, by means of a calorimeter, has experimentally determined the actual amount of force evolved during the oxidation of various organic materials. The substance examined is deflagrated with a mixture of chlorate of potash and peroxide of manganese in the calorimeter, and the heat evolved measured by the increase in temperature of a known quantity of water.

The following Table from Pavy gives his results :—

	Units of Heat evolved by oxidation of 15·422 grains as consumed within the body.
Grape Sugar (commercial)	3277
Starch (Arrowroot)	3912
Albumen (purified)	4263
Fat (Beef Fat)	9069

"The actual energy," says Frankland, "developed by the combustion of muscle in oxygen represents more than the amount of actual energy produced by its oxidation within the body, because, where muscle burns

in oxygen, its carbon is converted into carbonic acid, and its hydrogen into water—the nitrogen being, to a great extent, evolved in the elementary state; whereas, when muscle is most completely consumed in the body, the products are carbonic acid, water, and urea—a substance which still retains a considerable amount of potential energy."

Serious mistakes would, however, follow on the formation of a dietary based on the potential and actual energy of different articles of food; for it is found that substances which differ but slightly in their potential energy cannot be substituted the one for the other.

The relative values of food of the same class are also a matter of opinion, and both vegetarians and meat-eaters claim advantages for their respective diets. But whichever diet be adopted, two conditions are absolutely necessary—that the food be in a fit state for digestion, and that the secretions which it meets with in the alimentary canal be in a healthy condition to digest it, and prepare it for its ready absorption.

Another practical consideration enforced by all writers on diet is, that care must be taken to provide variety in the articles used as food so that they should contain the proper dietetic proximate principles.

The composition of milk has been suggested as the type on which a diet table should be formed.

Classification of foods based on the chemical nature of the principles :—

- 1. ORGANIC.
  - (*a*) Nitrogenous.—Albumen, etc.
  - (*b*) Non-Nitrogenous.
    - 1. Hydro-Carbons or Fats.
    - 2. Carbo-Hydrates or Sugars.
- 2. INORGANIC.
  - (*a*) Water.
  - (*b*) Saline Substances, etc.

It has also been found that it is impossible to substitute one constituent of food for another; all are essential, and health can only be maintained by a due proportion of each in the diet. With regard, however,

to vegetable and animal albuminates, it appears that these can be substituted for each other, and that nitrogenised vegetable products can replace animal products of the same nature. Animal food is more readily digested than farinaceous, and therefore supplies the wants of the system quicker; but, on the other hand, it has been asserted that the waste is greater in meat-eaters than in vegetable-feeders. The interchange between the fats and the carbo-hydrates does not appear possible; and with the admission that the subject is very obscure, I think we are not entitled to assert that the two groups of fats and carbo-hydrates are not so immediately and completely convertible as to permit us to place them together in a classification of diets. (Parkes.)

According to the same writer, during labour the muscles appropriate nitrogen, and grow instead of becoming wasted by oxidation and parting with their nitrogen, and that exhaustion does not so much depend on decay as upon the accumulation of the oxidised products of other kinds of food within their tissues. At one time it was also held that before the dynamical energy of the nitrogenous constituents of food could be obtained, they had to be converted into muscular tissue. The experiments of Drs Fick and Wislicenus during their ascent of the Faulhorn showed that a non-nitrogenous diet will sustain the body for a short period during exercise without a notable increase in the amount of urea excreted. Some decay of muscles does, however, take place if labour be long continued, and the amount of nitrogen must therefore from time to time be given if the work continue. The amount, however, of urea excreted during exercise appears to be more in relation to the amount of nitrogenous food taken than to the oxidation of muscular tissue to which muscular action was once ascribed. Hence, the amount of urea excreted is no index of the muscular work done. Some portion of the nitrogenous substances taken as food is most probably converted in the body into fat.

The experiments of Pettenkoffer and Voit go to show that nitrogenous substances have a direct or indirect influence on the oxidation of the other constituents of food, and that their participation is necessary for the manifestation of force. But for the mere production of force nitrogenous matter is far inferior to the hydrocarbons and carbo-hydrates, and it is not to the oxidation of muscular tissue that we are to look for the force produced. The muscles appear to be the instruments by which the force generated by the oxidation of non-nitrogenous matters is converted into working power. During oxidation a certain amount of heat is evolved, which becomes transformed into motive power, and this is expressed in foot-pounds, or the power required to lift one pound one foot high per unit of time—the unit of work.

According to Mr Joule, 772 foot-pounds represent the dynamic equivalent of 1° F.; that is, the heat required to raise the temperature of one pound of water 1° F. constitutes the equivalent of power required to lift one pound 772 feet high. By measuring with the calorimeter, the amount of heat evolved by the complete oxidation of different substances, Frankland was enabled to calculate the force-producing value of various articles of food.

The nutrient value of food has been classed under two heads—nitrogenised, or "flesh-forming," and carbonaceous, or "heat and fat producing;" but such a hard-and-fast classification is probably incorrect. The nutritive value of food is generally written in grains of nitrogen and of carbon. The daily diet of an adult man, according to Dr Edward Smith, should contain at least 4300 grains of carbon and 200 of nitrogen; but this appears too low, Dr Letheby considering that an adult in active employment ought to have 6823 grains of carbon and 391 of nitrogen.

These statements have been borne out by experiments made to ascertain the amount of carbon and nitrogen

excreted under different conditions of diet and exercise. Two pounds of bread and three quarters of a pound of meat will just about supply the daily amount of nitrogen and carbon required.

In the formation of a dietary, the following points have to be considered :—

1. Sex.—The dietaries of women should be one-tenth less than those of men.

2. Age.—A child at ten years of age will require half as much food as an adult woman, and at fourteen quite as much. Young men require almost as much food as adult men if engaged in the same employment.

3. Selection. — Variety, digestibility, relative proportions of proximate principles, number and distribution of meals.

The above will all require the careful attention of the medical officer of health, for Dr Wilson found that, in convict prisons, those engaged in hard labour lost weight on a diet of 225 grains of nitrogen and 5289 grains of carbon, and had from time to time to be shifted to light work to recruit; while those on light labour found a diet of 224 grains of nitrogen and 4651 of carbon sufficient to maintain health and bodily vigour.

The following Table is from Moleschott, adopted by Parkes :—

Standard Diet for a Male European Adult of average Height, 5 ft. 6 in. to 5 ft. 10 in., and average Weight, 140 lbs. Avoir. (66 kilogram.) to 160 lbs. (72·7 kilogram.), in Moderate Work.

DRY FOOD.	Oz. Avoir.	Grains.	Grammes.
Albuminous Substances	4·587	2006	130
Fatty Substances	2·964	1296	84
Carbo-Hydrate Substances	14·257	6234	404
Salts	1·058	462	30
Total Water-free Food	22·866	9998	648

Allowing for the quantity of fluid taken daily, the diet in the above Table represents the amount of force produced equal to 3900 foot-tons (PAVY).

The force produced by the oxidation of one ounce (437·5 grains) as consumed within the body—

	Foot-Tons.
Albumen (purified)	162·20
Fat (beef fat)	351·56
Starch (arrowroot)	157·66

This Table gives the potential energy expressed in foot-tons of the following substances—

		Foot-Tons.
One ounce of	uncooked beef yields	50
"	cooked meat	160
"	dried bacon	179
"	bread	88
"	oatmeal	130
"	potatoes	33
"	butter	339
"	eggs	68
"	milk (cow's)	27
"	sugar (lump)	129·5
"	arrowroot (starch)	151·3
"	ale	30
"	porter	41·3
"	albumen (dry)	174·0
"	fat	378·0

Hence, how much potential energy in foot-tons will be developed by 6 oz. of oatmeal, 8 oz. of cooked meat, 3 oz. of bread, and 20 oz. of milk when oxidised in the body?

		Foot-Tons.
6 oz. of oatmeal	130 × 6 =	780
8 " cooked meat	160 × 8 =	1280
3 " bread	88 × 3 =	264
20 " milk	27 × 20 =	540
		2864

In estimating the nutritive value of food, the value should be calculated from an analysis of the raw materials.

The following abridged Table is taken from Dr Letheby's work on Food :—

	Grains per Pound.			Grains per Pound.	
	Carbon.	Nitrogen.		Carbon.	Nitrogen.
Split Peas	2699	248	Cheddar Cheese	3344	306
Oatmeal........	2831	136	Mutton........	1900	189
Indian Meal....	3016	120	Beef	1854	184
Seconds Flour ..	2700	116	Fat Pork	4113	106
Potatoes	760	22	Bullock's Liver	934	204
Baker's Bread ..	1975	88	Beer and Porter	274	1
Turnips	273	13	White Fish	871	195
New Milk	599	44	Skimmed Milk..	438	43

From the above Table the amounts of carbon and nitrogen in any given diet may be calculated.

How much oatmeal, milk, and butter should be in a model diet? Are the salts in proper proportion?

	Albumen.	Fats.	Carbo-hyds.	Salts.
Oatmeal.........	12	6	60	3
Milk.............	4	3	5	0·7
Butter...........	—	84	—	2

$x =$ oatmeal. $y =$ milk. $z =$ butter.

(1) $\dfrac{12x + 4y}{100} = 4·5$ oz. Standard Albuminoids$=4·5$ oz.

(2) $\dfrac{6x + 3y + 84z}{100} = 3$ oz. Standard Fat $= 3$ oz.

(3) $\dfrac{60x + 3y}{100} = 14·25$ oz. Standard Carbohydrates$=14·25$ oz.

First, if $\dfrac{12x + 4y}{100} = 4·5$

then $12x + 4y = 450$

In the same way—

$$6x + 3y + 84z = 300$$

and $60x + 5y = 1425$

Taking equations (1) and (3)—

$$\begin{aligned} 60x + 20y &= 2250 \\ 60x + 5y &= 1425 \\ 15y &= 825 \\ y &= 55 \end{aligned}$$

In (1) if $y = 55$
$4y = 220$
$\therefore 12x = 230$
$x = 19{\cdot}16$

Taking (2) as $x = 19{\cdot}16$
$6x = 114{\cdot}76$
as $y = 55$
$3y = 165$

$\therefore 6x + 3y = 279{\cdot}76$

This taken from 300
$279{\cdot}76$
$20{\cdot}24$

$\therefore 84z = 24{\cdot}24$
$z = {\cdot}24095238 =$ nearly $\frac{1}{4}$ oz.

Thus $x = 19{\cdot}16$ oz.
$y = 55{\cdot}00$ oz.
$z = {\cdot}24095238 = \frac{1}{4}$ oz.

The salts are about normal, the standard being 1 oz.

Oatmeal contains	3 per cent.	$\therefore 19{\cdot}16 \times 3 \div 100$	$= {\cdot}5748$
Milk "	0·7 "	$\therefore 55 \times 0{\cdot}7 \div 100$	$= {\cdot}385$
Butter "	2· "	$\therefore {\cdot}2409 \times 2 \div 100$	$= {\cdot}0048$
			·9646

How much cooked beef and bread is required to provide enough nitrogen and carbon per day in model proportions for a healthy adult in average work?

(1) Bread contains per ounce, N 5 grains, C 120
(2) Beef " " N 15 " C 64

Let x = amount of beef in ozs. Let y = amount of bread in ozs.

Normal diet—300 grains nitrogen, 4800 carbon.

(1) $15x + 5y = 300$
(2) $64x + 120y = 4800$

Multiply (1) by 64 and (2) by 15.

(2) $960x + 1800y = 72000$
(1) $960x + 320y = 19200$

$1480y = 52800$
$y = 35{\cdot}675$

In (1) If $y = 35{\cdot}675$
$5y = 178{\cdot}375$
$\therefore 15x = 121{\cdot}625$

Ans. $x = 8{\cdot}1083$ oz.
$y = 35{\cdot}675$ oz.

Since $15x + 5y = 300$
and $5y = 178{\cdot}375$.
$\therefore 15x = 121{\cdot}625$
and $x = 8{\cdot}1083$.

In some calculations it may be necessary to determine the percentage composition of a substance. This may be done by the following simple rule :—To find the percentage composition of a compound from its formula, multiply the amount of each element present by 100 and divide by the molecular weight of the compound. Thus, required percentage of nitrogen in urea—

Urea, $CO N_2 H_4$

$$
\begin{aligned}
C &= 12 \times 1 = 12 \\
O &= 16 \times 1 = 16 \\
N_2 &= 14 \times 2 = 28 \\
H_4 &= \ \ 1 \times 4 = \ \ 4 \\
& \qquad\qquad\quad \overline{60}
\end{aligned}
$$

$60 : 100 :: 28 : x. \qquad x = 46{\cdot}67$ per cent. of N.

A man is allowed 6 oz. of meat and 20 oz. of bread per day, how much oatmeal must be added in order that the albuminoids in his diet may be sufficient? Would the diet thus constituted contain sufficient fat?

Composition per cent.—

	Albuminoids.	Fat.
Meat............	15	8
Bread...........	8	1·5
Oatmeal.........	12	6

	In work.	Idleness.
Daily requirements of albuminoids, ...	4·48	2·73
" fats or carbonaceous food,	26·44	20·60

Meat, 15 per cent. of 6 oz. = ·9
Bread, 8 " 20 oz. = 1·6
2·5

Required amount of albuminoids,...... 4·48
2·5
1·98 still required.

Oatmeal 12 per cent.

The number, multiplied by ·12, which will give 1·98 is 16, hence 16 oz. of oatmeal required.

The fats are in excess—

8 per cent. of 6 oz. = ·48
1·5 " 20 oz. = 30·00
30·48
26·44
4·04 fat in excess.

One other subject remains for consideration. What is the dietetic value of alcohol? On this most important subject no two opinions agree, but it appears certain that in very cold and in very hot climates the use of alcohol is positively injurious.

The following are the physiological and dietetic values of alcohol as summed up by Dr T. L. Brunton:

1. Alcohol, in small quantities, increases the secretion of the gastric juice and the movements of the stomach, and thus aids digestion. Although unnecessary to health, it is useful in exhaustion and debility.

2. It increases the force and frequency of the pulse, by acting reflexly through the nerves of the stomach.

3. In large doses it impairs digestion by over-irritating the stomach.

4. After absorption into the blood, it lessens the oxidising power of the red blood cells. This property renders it useful in reducing the temperature. When constantly, or very frequently, present in the blood, it causes accumulation of fat and fatty degeneration of organs.

5. It undergoes combustion in the body, maintains or increases the body weight, and prolongs life on an insufficient diet. It is therefore entitled to be reckoned as a food.

6. If large doses be taken, part of it is excreted unchanged.

7. It dilates the blood-vessels, increases the force and frequency of the heart by its action on the nervous centres, to which it is conveyed by the blood, imparts a feeling of comfort, and facilitates bodily and mental labour. It does not give additional strength, but merely enables a man to draw upon his reserve energy. It may thus give assistance in a single effort, but not in prolonged exertions.

8. The same is the case with the heart; but in disease, alcohol frequently slows instead of quickening the pulsations of that organ, and thus economises instead of expending its reserve energy.

9. By dilating the vessels of the skin, alcohol warms the surface at the expense of the internal organs. It is thus injurious when taken during exposure to cold, but beneficial when taken after the exposure is over, as it tends to prevent congestion of internal organs.

10. The symptoms of intoxication are due to paralysis of the nervous system; the cerebrum and cerebellum being first affected, and then the cord, and lastly the medulla oblongata. It is through paralysis of the medulla that alcohol usually causes death.

11. The apparent immunity which drunken men enjoy from the usual effects of serious accidents, is due to the paralysis of the nervous mechanism, through which a shock would be produced in a sober condition.

Characteristics of Good Meat.

Good and wholesome meat—*beef* or *mutton*—should present the following characters, which can be very readily observed:—On section, good meat should present a marbled appearance, and be of a pale, slightly brownish-red colour, neither too pale a pink nor too dark a purple. If pink and moist, disease is indicated; if purple and livid, it suggests that the animal most probably died with the blood in it, or had suffered from fever. The meat from healthy *slaughtered* animals should be firm and elastic, have little or no odour, and should dry on the surface if kept a day or two. Bad meat may easily be known by a moist and flabby appearance, accompanied with a sickly odour, which may be more easily detected by chopping up portions of the meat and drenching it with warm water. A clean knife may be plunged into the meat and then put to the nose, when any taint will be detected. Good meat should not shrink or waste much in cooking. The juice should be neither alkaline nor neutral, but slightly acid.

Pork, not salted, should, in all respects, resemble other good meat, excepting the colour, which ought to be a very pale red tint when sound. When of a dark colour, the presence of the dangerous parasite *Trichina spiralis* may be suspected, and the meat most carefully examined by means of a magnifying glass, as the unaided eye cannot be relied on. The sac of the *Cysticercus* or measle, which is often as large as a hemp seed, is easily seen, especially in the psoas muscles.

Sausages are liable to partial decomposition, when they then become poisonous. Sound sausage meat may be known by its firmness and its freedom from any unpleasant odour, and possesses a moist gelatinous or vesicular appearance.

Table giving the Causes and Effects of Diseased Meat and Milk.

I.—EXISTENCE OF PARASITES.

1. *Measly Pork.—Cysticercus cellulosis*, found in all parts of the flesh. Worm enclosed in a bladder about the size of a hemp seed ; rare in sheep and oxen. The measle worm of the pig becomes the *Tœnia solium* in man, that of oxen the *Tœnia medio-canellata.* Cooking destroys the worm.

2. *Trichiniasis.—Trichina spiralis*, found chiefly in the pig as a spiral worm in a calcareous cyst. If these enter the stomach of man, the cyst is dissolved, worm set free, produces young in large quantities, which then migrate to the muscles, causing severe fever, pain, and death. Cooking, unless *perfect*, does not destroy the worm. Salting is useless.

II.—INFECTIOUS DISEASES.

(*a*) Rinderpest. (*b*) Anthrax. (*c*) Pleuro-pneumonia.
(*d*) Foot-and-mouth disease.

Evidence uncertain as to the effect of eating the flesh of animals affected with these diseases. In some cases serious symptoms, in others none. Professor Gamgee states that at one time one-fifth of the common meat eaten in England was obtained from animals killed in a state of disease. The safe course is to reject all flesh of affected animals.

III.—POISONOUS SUBSTANCES TAKEN BY ANIMALS, THOUGH NOT NECESSARILY INJURIOUS TO THEM.

Ox treated with tartar emetic.—
Flesh poisonous, causing severe disorders.

Canadian partridges feeding on certain unknown berries.—
Flesh poisonous, causing severe disorders.

Hares eating *Rhododendron chrysanthemum.*—
Flesh poisonous, causing severe disorders.

Goats eating colchicum.—
Milk poisonous, causing severe disorders.

IV.—DECOMPOSED MEAT.

Action uncertain—high game. Sometimes an acrid, fatty acid is formed, giving rise to gastric disorders. The formation of Ptomaïnes may account for the poisoning effects of certain "canned" or "tinned" meats.

UNSOUND MEAT, ETC.

The Public Health Act, 1875.—Any Medical Officer of Health or Inspector of Nuisances may, at all reasonable times, inspect and examine any animal carcase, meat, etc., exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man ; and if any such animal carcase, meat, etc., appears to such medical officer or inspector to be diseased, or unfit for the food of man, he may seize and carry away the same himself, or by an assistant, in order to have the same dealt with by a Justice.

Justices may order destruction of unsound meat, and impose a penalty not exceeding £20 for *each piece* of meat, etc., so condemned.

A penalty of not more than £5 may be imposed on any one hindering an officer from inspecting meat, etc.

A warrant may be granted by a Justice on complaint made on oath by a Medical Officer of Health, or by an Inspector of Nuisances, or other officer of a Local Authority, to allow such officer to enter any building or part of a building in which such officer has reason for believing that there is kept or concealed any animal carcase, etc., unfit for food. Penalty for obstructing such officer not exceeding £20.

CLOTHES.

The blood of man remains nearly at the same temperature irrespective of the changes of temperature to which he may be subjected. By the use of clothes, man adapts himself to all temperatures and counteracts by their use the loss of heat by radiation, evaporation, and conduction. The heat of his body is radiated to the inner surface of his garments, and then passes through and from them by conduction and radiation. The heat is therefore, by the use of clothes, kept longer near our bodies—the thinnest veil keeping the face warm by arresting the radiated heat. The textures most permeable to air keep us warmest, air being one of the worst conductors of heat ; uncompressed wadding is, therefore, warmer than when compressed. The air which reaches our bodies has also been prepared for us by our

clothes, and the differences of temperature between our bodies and the surrounding atmosphere equalised in the meshes of the cloth. Clothes act on the same principle as the double window-sashes used in cold climates—the layer of air between them keeping the heat in the room. Our clothes do not therefore keep us warm by excluding air from our bodies, for were this so, kid would be warmer than flannel. Tight-fitting clothes are not so warm as loose made ones. The heat of animals is maintained by the air in their fur, which never becomes cold except at the tips. India-rubber clothes prevent evaporation by limiting the change of air in the under garments; they therefore become inconvenient in damp, warm weather, but may be worn in wet, cold, windy weather. Wet clothes, the air in their meshes being displaced by water, keep us less warm than when dry, because water is a better conductor of heat than air, and the evaporation of the water in them also cools the surface of the body. Hence also the ease with which we take cold in wet linen or silk as compared to wool, which absorbs water slowly. The quicker the air is expelled the more likely are we to take cold, as the body chills rapidly. Our bed-clothes should be light, airy, and warm. There is a constant circulation of air from the bottom to the top of the bed; and as during sleep less animal heat is produced, the appropriateness of the bed-clothes becomes even more important than our day clothes.

DWELLING-HOUSES.

In this country it is no easy matter in the neighbourhood of towns to select the site one would wish, but it is open to every one to see that his future residence is well built, properly drained, and that every sanitary improvement is adopted to prevent disease, and ensure

the health of the residents. Rows of *back-to-back buildings* which do not permit of a free circulation of air round them should not be permitted, and where it is absolutely necessary to provide for a large number of persons on a given area, it is better to increase the height of the building on the model lodging-house plan than to house the people in a number of low houses with deficient means of air circulation. Where a choice of site is, however, permitted, a slight eminence, with a south-east aspect for the front of the house, should be selected, the larder, etc., being to the north. Houses situated in deep valleys are cold. (See page 530.) Habitations placed on the sides of hills are damp, as the ground above drains into them. To avoid this danger the hill should be cut away for some distance from the building so as to allow of drainage between the side of the hill and the house or hut, and this should always be done when it is necessary to provide a camp for an army on the slope of a hill. In camps, huts should be placed on well drained terraces and space allowed for a free circulation of air around each hut.

The following suggestions may be found useful :—

1. Careful drainage. (See page 571.)

2. When houses are being built on the site of old brick-fields, careful drainage of all pits and hollows left should be enforced before such pits or hollows are filled up.

3. Places filled up with cinder rubbish containing more or less vegetable and organic matters should not be built upon for at least two years from the date of the last deposit. The Public Health Act 1890 imposes a penalty not exceeding five pounds and a daily penalty not exceeding forty shillings on anyone erecting a new building on any ground which has been filled up with any matter impregnated with fæcal animal or vegetable matter.

4. Road scrapings should not be mixed with the cinder rubbish.

5. No wells should be sunk in such made-up ground.

6. The basements of all houses should have a good foundation of concrete, and a "damp-proof" course should be laid at such a

height as to prevent the possibility of the wall being wetted by the splashing of rain from the ground in wet weather. Dry areas may be adopted in some cases. Flower beds, etc., should not be raised against the walls.

7. Provision should be made for free ventilation under the floor. For this purpose iron gratings let into the walls, with the openings small enough to prevent the admission of mice, are better than perforated bricks.

8. The walls should be of the thickness required by the Metropolitan Buildings' Acts, 1855 (18 & 19 Vict., c. 122). The student had better procure this Act.

9. The walls may be built hollow, with tie bricks between each row of bricks.

The Cause of Damp Walls.—There is a certain amount of water used in the building, which may be called "building water." The laying of 100,000 bricks in the walls of a house would require, at least, 10,000 gallons of water. In old houses this has evaporated, and the pores in the wall have become filled with air; but in new houses the walls still contain a large proportion of this "building water," and being colder than the surrounding air, condense the moisture from the air on their surface; hence, the sudden appearance of damp on the walls. In old walls the moisture is, to a certain extent, immediately absorbed, and the dampness only appears when the superficial surface of the walls is saturated by the continued application of moisture. Some walls, which appear dry, suddenly become damp. This is due to the evaporation of the "building water" on the surface, or at least but for a short distance in the plaster, and the pores being only partially filled with air, soon becomes saturated, the air being displaced, and damp walls are the result. A fire in such a room, with the doors and windows closed, heats the portions of the walls nearest to it, causing the evaporation of the water in the walls, which water is condensed on the cold walls farthest from the fire. The more porous the walls are, the drier they will become.

How shall we find if a House be Dry?—Procure specimens of mortar from different parts of the house. These ought not to contain more than 5 per cent. of water. Some builders try the walls by putting their mouths to them and sucking them; if dry there is a peculiar sensation, like that experienced when a clean clay pipe is put for the first time in the mouth. As a means of rapidly drying houses, let fires be lighted in all the rooms and allow of constant ventilation.

ENDEMIC DISEASES.

The action of endemic influences on the animal economy was held by Cullen to be a direct sedative, not merely lowering the vital power, but also inducing spasm of the extreme capillaries. If the vital energy of the system were not entirely overpowered, reaction supervened, and fever became developed. Some hold the opinion that marsh effluvia acts as a stimulant or irritant, and that the debility which it evidently occasions is consecutive on a state of exhaustion. These opinions do not, however, explain all the phenomena of these diseases. Goitre, ague, and typhoid fever are endemic diseases; the latter may, however, become epidemic. The sources of endemics are—

1. Low marshy places.—Due, however, to the antiseptic property of peat, ague is unknown in the bogs of Ireland.
2. Ground subject to inundation, or saturated with moisture.
3. Woods, jungles, etc.
4. Presence of decaying animal and vegetable matter.
5. Polluted water.

Prevention.—Drainage, embankments, flooding the marshes with water—in fact, turning the marsh into a lake; clearing the soil of wood, and cultivating it. (See page 416.)

Rickets.—This disease appears to have first attracted attention in England about two-and-a-half centuries ago, and was first observed in the counties of Devon and Somerset. The origin of the name is somewhat obscure, it being considered by some to be a derivative of either a Dorsetshire verb "to rucket"—*i.e.*, to breathe laboriously, or of "rick" a hump or elevation. Trousseau holds that it is from a Norman word "riquets" applied to deformed persons. Glisson first gave to the disease the name Rachitis or Rhachitis. Whistler, about 1645, describes Rickitis as *morbus puerilis Anglorum*, hence the name among foreign writers *morbus Anglicus*, and it was supposed to have spread from England to the Continent. It is certainly a disease of damp cold climates, seldom attacking children before the sixth month or after the eighteenth, but it is essentially a disease of infancy, and must be distinguished from the different scrofulous, tubercular, or other kinds of softening of the bones seen in adults. Rickets is very common in Scotland, and is also frequently seen in England. According to Dr Gee, 30·3 per cent. of all the children under two years brought to him at the Children's Hospital, London, during 1867 were rickitic. Rickets is said to be more common in crowded cities than in the country. The treatment both curative and prophylactic is largely dietectic and hygienic. Proper and nourishing food, fresh air, tepid or cold baths. Rest in the recumbent posture for some hours of the day is also useful. Cod-liver oil and preparations of iron may be given.

Scurvy or *Scorbutus.*—Scurvy is a chronic disease characterised by general impairment of the health, sponginess of the gums, the occurrence of livid patches under the skin of considerable extent, bleeding from the mucous membranes and "hemeralopia," "nyctalopia," or "night blindness." The origin of scurvy is probably contemporaneous with the aggregation of masses of men

under insanitary and artificial conditions. The long voyages to the East round the Cape of Good Hope and to America gave rise to "Sea Scurvy," and the long sieges of former times to "Land Scurvy." The causes at work—improper food and bad hygienic conditions are the same. The prevention of scurvy is, therefore, to be found in removal of all insanitary conditions, the free allowance of lime juice, fresh vegetables, potatoes especially, and a frequent change of diet.

EPIDEMIC DISEASES.

Epidemic diseases are those diseases which prevail occasionally with unusual severity, and at uncertain intervals, attacking large masses of the people, and lasting in most cases for some months, and obeying a certain law of periodicity.

Miasm is held to be "an infectious matter arising *outside* the body," whereas contagion is a specific infectious matter arising *within* the body of the person.

Sources.—Certain endemic influences just mentioned; a condition of the atmosphere, of the exact nature of which we are utterly ignorant; and the presence of a specific germ. Some epidemics are peculiar to certain seasons, especially when those seasons have been more than usually prolonged or otherwise exaggerated, excessive heat or cold, etc. Sydenham remarks "that all epidemics are referable to one or two classes. They are either *vernal* or *autumnal.* Even when they originate during some other period of the year, they must be referred to one of these divisions, spring or autumn, whichever they are nearest to, just as the case may be. For it happens occasionally that the atmospheric influences may so coincide with an epidemic as to forward its development, and to precipitate it, as it were,

prematurely upon its victims." Epidemics are either indigenous or imported: to the former belong scarlet fever, typhus, small-pox, measles, etc.; to the latter, cholera, plague, etc. Indigenous epidemic diseases are always present in a sporadic form—when, from some unknown cause, they suddenly become epidemic, and go through the several stages of *increase*, *maximum*, and *decline.* Sometimes the epidemic is very fatal, at others mild; the characteristic eruptions at one time most marked, at another almost absent; the sequelæ may even differ in two epidemics of the same disease. The spread of epidemics is primarily due to contagion and infection. Two diseases may be epidemic at the same time—typhus and relapsing fever—but the one does not neutralise the other. The unrecognised existence of these diseases at the same time has given rise to the difference of treatment advocated by some observers. As long as susceptible persons are brought within the infected area, the epidemic continues. The end of an epidemic is held by some to result from the exhaustion in individuals of the special food of the germ of the prevailing disease. Imported diseases which become epidemic are generally absent for long periods—cholera, 1832, 1849, 1854, and 1866. The entire absence for a long period of an indigenous epidemic disease appears to militate against the the theory of disease germs.

The following Table gives examples of diseases which are—

Endemic.—Goitre, Ague, Rheumatism, etc.

Endemic and Infectious.—Relapsing Fever.

Epidemic and Infectious.—Typhus, Small-Pox, Scarlet Fever, etc.

Pandemic.—Diseases that have no special local habitat—*e.g.*, Small-pox, Measles, etc. There is a supposed pandemic wave.

Miasmatic Contagious Diseases.—Typhoid, Cholera.

Contagious, but not otherwise Propagated.—Syphilis, Vaccinia, Hydrophobia, etc.

Any condition, whether acting primarily within the body, or as the result of physical influences acting without, that tends to lower the vital powers, is favourable to the inception and spread of an epidemic. Thus, the excessive heat of summer, if prolonged beyond the usual limits, tends to lower the resisting power of the system, and favour the growth and spread of diseases most obnoxious to the state of exhaustion thus brought about. Famine and drought are fertile sources of epidemics, and to these two causes, to a great extent, was due the fearful mortality during the period from 1833 to 1851. Religious and other social conditions are all more or less instrumental in the spread or prevention of epidemics; and diseases occurring among the lower animals, and in those vegetables most used for food, also add their influence to the list of causes of epidemics. The failure of the potato crop led to the Irish famine, with its terrible results.

A few of the diseases that have occurred as epidemics, and the means for their prevention, will now be given.

Cholera.—This disease has prevailed as an epidemic in England at various times, but notably during the years 1832, 1849, 1854, and 1866, when the mortality was very great. The disease seldom prevails as an epidemic during winter, though it has done so in certain Russian towns.

Origin and Cause.—Of the origin of cholera very little is known, but it has been shown by Pettenkofer and other observers that three factors—place, time, and individual—are necessary for its spread, these being usually spoken of as the local, temporal, and individual disposition. Recent investigations have shown that a bacillus called the comma bacillus has been found in the intestines, in the discharges and mucous membrane, and also in the water which had been drunk by cholera patients. It can be cultivated in almost any medium,

best at a temperature of from 30° C. to 40° C., and measures about $\frac{1}{2}$ to $\frac{2}{3}$ the size of the tubercle bacillus. It is said to multiply outside the body, especially in water contaminated with organic matter. Although the advance of cholera towards and through Europe, the places attacked were ranged along the great traffic lines, still it was noticeable that, whilst Paris and Marseilles were almost depopulated, Lyons escaped. But, further than this, one part of a town suffered more than another. Munich, Berg, and Flaidhausen were examples of this. In these towns it was almost universally noticed that the houses on the limestone gravel were those attacked, whilst those on the brick clay almost entirely escaped. This singular fact may be explained by the amount of ground air contained in loose, moist soils not saturated with water, and which is hourly drawn into the houses whenever they are warmer than the surrounding atmosphere. In clay soils there is but little of this ground air, and hence the comparative freedom from diseases which it affords. On the other hand, it has been argued that in water-clogged soils, or stiff clay, the surface water has a tendency to run off horizontally, but in porous soils the water sinks into the soil, carrying the germs of the disease into the wells. During the epidemic in London, in 1849, it was noticed that while the deaths on the low-lying parts of the city were 174 per 10,000, the deaths at 350 feet above the river were only 6 per 10,000. This difference might have been due to the better drainage of the higher parts of the town. Of the individual conditions favourable to the reception of the poison we know nothing, for all are attacked, irrespective of age, sex, or position in life, the strong claiming no advantage over the feeble. The disease may be communicated—

1. By persons themselves in various stages of the disease.

2. Carriage of infection by healthy persons (?)

3. Soiled clothes.

4. Importation of choleraic discharges by bad sewers into wells and other sources of water supply.

5. Certain constituents of the soil of a place (PETTENKOFER).

6. Presence of the cholera poison in the air.

7. Introduction by food.

PRECAUTIONS, ETC.

1. Quarantine for twenty days at least.

2. House-to-house visitation.

3. Early treatment of the first symptoms of diarrhœa. The best medicines are laudanum, aromatic sulphuric acid dilute, camphor, the compound aromatic chalk powder, etc.

4. A most careful disinfection of the stools or other dejections of cholera patients before allowing them to enter the sewers.

5. In small towns having only cesspools, the stools, etc., should be disinfected, and buried deep in the earth as far as possible from human habitations.

6. If the season permit, the treatment of cholera patients is best conducted in tents.

7. Careful disinfection of houses by the usual methods, and prevention of ground air into them.

SMALL-POX.—This is the type of the zymotic class of diseases, and was first described by Rhazes, an Arabian physician. Natural or unmodified small-pox is now a rare disease, owing to the practice of vaccination It prevails chiefly in winter and spring, and appears to have a tendency to recur once in ten years. "There is no contagion so strong and sure as that of small-pox, none that operates at so great a distance." The disease may be spread by fomites, by infected rags in "rag and bone shops," by a dead body, etc. Small-pox is most fatal under five years, least between ten to fifteen, and again, more fatal after thirty. Dark-skinned races, especially negroes, suffer severely from small-pox. The period of incubation is about twelve days. The disease is ushered in with pains in the limbs and especially the *back*. Sudden chills and rigors, followed with an eruption on the third day of the fever.

The precautions to be taken against its spread are—

1. *Inoculation.*—This is not now legal, but there cannot be a doubt but that the inoculated disease is much milder than the natural.

2. *Careful Vaccination.*—This was once put forth as a perfect prophylactic to small-pox, but the repeated occurrence of epidemics of that disease has somewhat shaken the faith once reposed in it. This disappointment is due to—

(*a*) Absence of full statistics showing the mortality of the vaccinated compared with that of the unvaccinated.
(*b*) Medical men not stating in their death certificates if patients unvaccinated, or marks present if vaccinated.
(*c*) Vaccination not properly performed.
(*d*) The relative number of vaccinated and unvaccinated in the entire population.

The large *majority* of small-pox cases admitted into hospitals have been vaccinated. This may be due to two causes—

(*a*) That the bulk of the population is vaccinated.
(*b*) That vaccination has been improperly performed.

The proper view to take of vaccination appears to be this—that it does not prevent small-pox, but modifies its virulence; and this is borne out by hospital statistics which show that the mortality in the vaccinated is 5 to 9 per cent., in the unvaccinated, 49 to 71 per cent. It has also been stated that syphilis is propagated by vaccination. We believe that the statements made on this subject are overdrawn, and as animal lymph can be obtained from Governmental sources, this objection can scarcely now be entertained.

3. *Re-Vaccination at Regular Intervals.*

4. *Immediate Removal by Special Means of Conveyance of those attacked to properly regulated Hospitals or Tents.*—This is the more important when small-pox attacks, as it generally does, those living in ill-ventilated and densely-populated courts and alleys.

5. *Free Ventilation and Disinfection of the House*, by the use of chlorine, nitrous acid, and iodine vapour.

SCARLET FEVER is the type of an infectious malady, and recent investigations have more than suggested that it is probably a disease of cows transmitted to the human subject. The disease in cows which is supposed to give rise to scarlet fever occurs as small vesicles and

ulcers on the udder and teats. This is known as the "Hendon Disease." The strepto-coccus of scarlet fever was found in them, and a sub-culture of these given to calves produced the Hendon Disease. The poison appears to be less volatile than measles, but acts at a greater distance than typhus. It can be propagated in every possible way, even by letters sent by the post. Healthy persons may convey the poison without being themselves attacked. Schools frequently spread the disease. Scarlet fever is most prevalent in Autumn, the mortality being highest in October and November. The death rate is highest in young children that is under five years, adding about 0·5 per 1000 to the death-rate. Scarlet fever may disappear for three or four years and then reappear, due probably to the fact that the liability to the disease during the first year is almost *nil*, that it increases up to the fifth year and then declines. For a few years after an epidemic the community is thus to a great measure protected. More females are attacked, but more males die. The susceptibility to the disease diminishes after the fifth year. The period of incubation varies from a few minutes to five days, seldom exceeding six days (MURCHISON). The eruption preceded by chills, rigors, sore throat, vomiting, and intense heat of the skin appears on the second day of the fever.

"You will be asked," says the late Sir Thomas Watson, "at what period the danger of imparting the disease on the one hand, or of catching it on the other, is over; and I would recommend you to answer that you do not know. I am sure I do not, and therefore I always decline the responsibility of giving an oracular opinion on the matter." The more actively contagious period of the fever is uncertain. Some consider the period of desquamation, and therefore recommend inunction to prevent the scales flying about in the room. The predisposing causes are those which lower the vital powers —overcrowding, etc. Prophylaxis, none.

PREVENTION OF SPREAD.

1. Isolation.

2. Exposure of clothes, etc., to dry heat or boiling water.

3. Fumigation of rooms with fumes of sulphur. Close all doors, windows, and chimneys, and burn from 1 to 2 ℔s. of sulphur for every 1000 cubic feet of space. After some hours, open room and allow free ventilation.

4. Destruction of all infected articles.

5. Inunction of lard to prevent escape of epithelial scales, and the free use of soap and water.

MEASLES.—*One* of the *exanthemata*, and propagated in a like manner as scarlet fever, and as a rule recurring every third or fourth year. The mortality at all ages is about 0·4 per 1000, but under five years it amounts to 2·8 per 1000 living. The mortality is probably due to inter-concurrent capillary bronchitis which is a most fatal disease among young children. Though comparatively a mild disease in this country, measles, when introduced to a new land is most fatal. It nearly depopulated the South Sea Islands, as small-pox did the central and northern parts of North America. This severity is supposed to be due to the abundance in the blood of the fit pabulum for the germs of the disease, and which has not been previously partially exhausted by the germs of the other exanthemata. The period of incubation is from ten to fourteen days, and the eruption after a preliminary catarrhal attack appears on the fourth day of the disease.

Prevention.—Measures like those for scarlet fever.

EPIDEMIC INFLUENZA.—The grip. In 1729 there "broke out and raged all over Europe and perhaps the globe, a most universal epidemic catarrh," and in 1732-33, says Dr Guy, quoting from Dr Short, "the most sudden and universally epidemic catarrh that has been in this age, sparing neither ranks, sexes or ages, old or young, weak or strong, and killing off many

hectic and phthisical people." "In the space of twenty-five years," says Dr Guy, "four well-marked epidemics of influenza occurred, this is in the years 1729, 1733, 1737, 1743." Within the last two or three years a severe epidemic has also occurred. The disease does not appear to be connected with any insanitary condition, and the symptoms and after effects have varied considerably among those attacked. Influenza spreads rapidly among all classes of a community, and this rapidity points to the air as the medium by which the contagion—said to be a micro-coccus, is carried. The period of incubation is about two days. In some cases the respiratory tract was most affected, in others the alimentary tract suffered most, in still a third class of cases rheumatic pains in the joints and limbs were most severe. There was in all cases high temperature and much nervous depression.

Preventive Measures.—Isolation of those attacked, and aërial disinfectants.

Diphtheria.—The distribution of this disease is peculiar to itself, and the mortality from the disease does not appear to be regulated by the same causes that influence the general mortality, for density of population does not appear to favour it. It seems to have a preference for certain special districts, the great majority of which may be described as rural. The development of low vegetable organisms have, it would seem, more to do with the origin of diphtheria than the defective sewers and the higher sanitary developments of civilization. Even privies and ashpits cannot be charged with its origin, for in towns where these abound the presence of diphtheria is by no means frequent. It is most frequently present in the rural districts of Ontario, Canada, though there cannot be a doubt but that pharyngitis with follicular secretion has often been mistaken for it, with many vaunted cures. It has been also suggested that it may be due to some

unknown disease among the lower animals with which rural are more frequently brought into intimate relation than urban communities. There appears also to be an individual susceptibility to the disease which may be even shown to be, in some cases at least, hereditary. The true cause may probably be detected some day among the numerous mould-fungi, at least present evidence points in that direction. Diphtheria chiefly attacks children between the ages of 2 and 10 years, and is most prevalent in the autumn or fall of the year.

Preventive Measures. — Perfect isolation of those attacked, careful disinfection of all articles brought in contact with the patient, and the correction of all insanitary defects.

Note.—The false membrane is said to be *croupous* when the epithelium of the mucous membrane is alone involved; *diphtheritic* when the deeper layers of the mucosa are affected.

Splenic Fever.—This disease is known as anthrax, charbon, malignant pustule, wool-sorters' disease, splenic fever, and splenic apoplexy. This disease, known under so many names, is found among cattle, horses, and sheep, but less commonly among swine and dogs, and is said to be caused by a bacillus, *the bacillus anthracis.* The disease can be communicated to man from the lower animals, and in both may occur under two forms (1) local, (2) general, the former being chiefly manifested in man. In animals there is but little local lesion, the chief changes being found in the spleen, which becomes thoroughly disorganised, resembling a mass of blood-clot, hence the name splenic apoplexy. Hæmorrhages may occur in other organs, and serous inflammations with effusion may also be present. The blood is of a dark colour and is crowded with bacilli. In animals, but less so in man, the lymphatic glands are affected. The bacilli may be found in almost any part of the

body of the animal or man attacked by the disease, but no spores are found in the blood. Anthrax occurs among persons working amongst hides, hair of cattle, etc., hence wool-sorters and tanners. Flies also probably carry the poison, especially if they alight on any abraded surface of the body, hence anthrax or malignant pustule may result from inoculation. The pustule does not contain pus, its presence being marked by a small hard pimple, surrounded by a bluish inflammatory zone which rapidly increases, and a local gangrene and necrosis of the tissues ensue. Fresh vesicles or bullæ in the course of the disease may form round the primary one, and general blood poisoning may ensue. In the general form of the disease, of which malignant pustule is the local form, the respiratory tract is affected; woolsorters' disease, on the gastro-intestinal tract, giving rise to diffuse inflammation, etc.

The bacillus anthracis occurs in the blood in the form of motionless straight rods joined end to end, with blunt slightly curved extremities. There are no spores in the blood, these being found only in the kidney. The bacilli vary from 5 to 20 μ. in length, and 1·2 μ. broad, and can be grown on gelatine, potatoes, agar-agar, in hay infusions, and in aqueous humour. They appear to require oxygen for their growth, but are killed by an excess. Continued dryness destroys them, but they are not affected by freezing.

Glanders and Farcy.—Glanders is an inflammatory affection of the nasal mucous membrane, produced by the contagion of matter from a glandered horse. The bacillus is the *bacillus mallei*, and it has been proved to be the contagium of glanders, as that disease can be caused by inoculation in horses, donkeys, etc., with it. In horses glanders is frightfully contagious and incurable. Farcy is an inflammatory affection of the skin, and of the absorbent system, produced by the contagion of matter from a horse having glanders or farcy.

Rabies.—Rabies is a disease common to many animals, especially those of the family *canedæ* of which the wolf and domestic dog are types. There is no aversion to water among dogs, and in this particular rabies in the dog differs from the disease when inoculated in man, and to which the name hydrophobia is properly given. It has been proposed that all dogs should be muzzled, registered, and wear a collar with the owner's name and address, and all vagrant dogs killed. Suspected animals should also be killed or quarantined and muzzled. Pasteur, by means of inoculations of the virus of varying strengths has successfully treated many cases of the disease in man, reducing the death-rate from 15 per cent. in the unprotected to 1·36 per cent. in the protected.

Leprosy.—Elephantiasis Græcorum, lepra vera. The only European country where leprosy is still common is Norway, but it is also found in Sicily, Malta, parts of Portugal, the Levant, Crimea, in some parts of the East Indies, Africa, Central America, etc. Leprosy may be divided into two varieties, which, however, often exist together, the *nodular* or "tubercular" and *anæsthetic.* In some cases either variety may be preceded or accompanied with pigment spots, hence a third species, *lepra maculosa.* The disease may begin insidiously, accompanied with an outburst of bullæ, then violet or red patches varying in size, raised nodules and infiltration of the deeper parts of the skin. The lymphatic glands enlarge. The nodules may shrink, leaving atrophied pigmented spots. Sometimes ulcers are formed. The course of leprosy is very slow, and there is very little pain. The general condition of the patient is little affected in spite of the steady continuance of the disease to a fatal conclusion. Death is generally due to some intercurrent disease, pneumonia, pleurisy, etc., which the general condition of the patient at last renders more than usually fatal. The cause of leprosy is unknown, the prognosis unfavourable, and treatment almost hopeless.

Typhus.—The result of a specific poison probably of animal origin, apparently generated by overcrowding or ochlesis (ὄχλος, a crowd). Murchison maintained that the disease sometimes arose, *de novo*, and gives three cases where typhus appeared, but no possible source of infection could be traced. In his cases the persons attacked were huddled together in a small room without any pretence at ventilation. The poison is not very volatile, and is almost entirely destroyed by free ventilation. Starvation, penury, want, and overcrowding, are the predisposing and exciting causes of typhus.

Prevention.—Complete isolation of those attacked, free ventilation, and perfect cleanliness of everything used by the patient. The evolution of nitrous acid gas has been found of great use. The clothes of patients should be placed as soon as removed into boiling water, or into an oven and baked. Treat in tents or temporary wooden huts, or place patient in the top room of a house, as the poison has a tendency to rise.

Typhoid.—This is essentially a filth disease. Typhoid fever is propagated chiefly by the discharges from the bowels, and probably, as in typhus, the result of the admission of a poison of animal origin into the blood. The poison may be carried by water, and by food, as in the case of the outbreaks in Islington and in the west-end of London, where the carriage of the poison was traced to the milk used by those attacked. The common domestic fly may not improbably be a carrier of the poison from sewage to our food.

Prevention.—The isolation of the afflicted, and the most rigid attention to the proper disinfection of the stools with zinc chloride, ferrous sulphate, etc. "Never empty any evacuation into a closet, sewer, or cesspool; bury it several feet deep, and mix it well with earth" (Parkes). The clothes and bedding should be well fumigated and exposed to a temperature of at least

240° F. The purity of the drinking water, and the most efficient drainage, are absolutely necessary to prevent a future outbreak, and to arrest the existing one. Treat in tents, as in the case of typhus.

Relapsing Fever.—An infectious disease of uncertain origin, sometimes following periods of great scarcity, and certainly spread by overcrowding. It is endemic in Ireland and Silesia, sometimes becoming epidemic. Sir R. Christison spoke of its "spontaneous generation" from "penury, pent up in airless dwellings," as beyond doubt. Bacteria spirochætæ have been found in the blood of those attacked, disappearing with the remission of the symptoms and reappearing in the acute stage. No spores have been detected, and the spirillum has not been found in the tissues. Monkeys have been inoculated with the disease, and it has been transmitted from man to man.

Diagnosis.—After great depression in trade towards the end of the autumn quarter, the disease may set in with rigors, followed with sharp fever, vomiting, and epigastric tenderness, these symptoms subsiding with copious sweating about the fifth to the seventh day, but mostly recurring after the lapse of about a week, being then sometimes accompanied with jaundice and hæmorrhages, the symptoms again disappearing after copious sweating.

Yellow Fever.—A malignant epidemic fever, usually continued but sometimes assuming a paroxysmal type, characterised by yellowness of the skin, and accompanied in the severest cases with hæmorrhage from the stomach (black vomit) nose and mouth. Yellow fever is essentially a disease of tropical climates seldom extending beyond 40° north and 20° south latitude, and requiring a temperature of 72° F. at least to produce and spread it. It rarely occurs above 2500 feet from sea level. Yellow fever appears to be due to the

accumulation of fæcal matter round crowded and badly ventilated habitations, barracks, etc. The negro race appears to possess an absolute immunity from this fever, whereas the white races are most susceptible, especially new comers into the yellow fever zone. The disease is not apparently due to malaria.

Prevention.—Good food and the other measures recommended for typhus.

The following Diseases are supposed to spread by Infection contained in the fæces of the sick:—Yellow fever, cholera, and typhoid fever, though, as in the last disease, persons convalescent may carry the disease. Parkes suggests that this may be the result of badly washed clothes.

It may also be asked, What are the Diseases which nearly all physicians and surgeons admit would almost be best treated in the open air, in tents, etc.?—Erysipelas, cholera, small-pox, typhus, and typhoid fever, yellow fever, hospital gangrene, etc., etc. In the case of scarlet fever and measles, patients should not be exposed to cold, but in no case is free ventilation contra-indicated.

The classification of the Registrar General of communicable diseases is as follows. Six orders:—

SPECIFIC, FEBRILE, OR ZYMOTIC DISEASES.

1. Miasmatic Diseases.—Eruptive fevers, influenza, pertussis, epidemic pneumonia.

2. Diarrhœal.—Enteric, simple continued, cholera, dysentery, diarrhœa, etc.

The seven principal diseases of the zymotic class belong to Orders 1 and 2.—(1) small-pox, (2) measles, (3) scarlet fever, (4) diphtheria, (5) whooping-cough, (6) diarrhœa, (7) fevers: typhus, enteric, and simple continued (febricula).

3. Malarial diseases.

4. Zoögenous diseases include vaccinia, rabies, glanders, splenic fever.

5. Venereal diseases.

6. Septic diseases include erysipelas, pyæmia, septicæmia (puerperal and non-puerperal).

THE MEANS BY WHICH ZYMOTIC DISEASES ARE SPREAD.

1. Difficulty of isolating the sick.
2. The sale of infected clothing, etc., in rag shops.
3. The letting of infected houses and apartments, schools.
4. Incautious conveyance of the sick in cabs, etc.
5. Convalescents, laundresses, tailors, etc.
6. Foul water, bad drains, etc.

INFLUENCES UNDER WHICH ZYMOTIC DISEASES ARISE.

The causes which appear to influence the rise and spread of zymotic diseases may be tabulated thus :—

(1) Those which belong more particularly to Locality.

(2) Those which depend upon Population.

I.—THOSE OF LOCALITY.

1. Locality.—This can scarcely be considered in old established countries, and is more important in countries where new communities are being formed; for then it may be stated that the higher the situation above sea-level the greater freedom from zymotic diseases.

2. Drainage —Bad condition or absence of W. C.

3. Age, Construction, and Condition of Houses and Streets.—The effect of these causes is notably seen in all old towns—such as Edinburgh, Dublin, London, etc.

In the old town of Edinburgh, fever is almost endemic; and the same appears to be the case in Dublin. (See Report of Dublin Sanitary Association, 1873.) The narrow streets in the old town of Edinburgh, combined with the age and filthy condition of the houses, the density and poverty of the population, all tend to localise fever in these parts.

4. Season and Climate.—These have been mentioned before.

II.—THOSE OF POPULATION.

1. Density of Population.—The unhealthiness and increased death-rate due to this cause have been discussed elsewhere.

2. Pauperism.

3. Cleanliness.—This is almost absent in poor districts, dirt prevailing everywhere.

4. Improper accommodation for the Sick.

The Public Health Act, 1875.

INFECTIOUS DISEASES AND HOSPITALS.

Any Local Authority on the certificate of their Medical Officer of Health, or of *any other* legally qualified medical practitioner, stating that a house requires disinfecting and cleansing, or any articles therein likely to retain infection, shall give notice in writing to the owner or occupier, requiring him to cleanse and disinfect such house and articles, within a specified time. If the person fail to comply therewith, he shall be liable to a penalty of not less than one shilling, and not exceeding ten shillings, for every day during which he continues to make default; and the L.A. shall cause such house, or part thereof, and articles, to be cleansed and disinfected, and may recover the expenses incurred from the owner or occupier. Where the owner or occupier of any such house is, from poverty or otherwise, unable to carry out the requirements of this Section, the L. A. may, with his consent, cleanse and disinfect such house and articles, and defray the expenses thereof.

Any L. A. may direct the destruction of any bedding, clothing, or other articles which have been exposed to infection from any dangerous infectious disorder, and may give compensation for the same.

And may also provide a proper place, with all necessary apparatus and attendance, for the disinfection of bedding, clothing, or other articles which have become infected, and may cause any articles brought for disinfection to be disinfected free of charge.

Any L. A. may provide and maintain a carriage or carriages suitable for the conveyance of persons suffering under any infectious disorder, and may pay the expense of conveying therein any person so suffering to an hospital or other place of destination.

Where any suitable hospital or place for the reception of the sick is provided within the district of a L. A., or within a convenient distance, any person suffering from any dangerous infectious disorder, and is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel, may, on a certificate signed by a *legally qualified medical* practitioner, and with the consent of the superintending body of such hospital, be removed, by order of any Justice, to such hospital or place at the cost of the L. A.; and any person so suffering, who is lodged in any common lodging-house, may, with the

like consent and on a like certificate, be so removed by order of the L. A.

Any person who wilfully disobeys or obstructs the execution of such order, shall be liable to a penalty not exceeding ten pounds.

Any person who—

1. While suffering from any dangerous infectious disorder, wilfully exposes himself without proper precautions against spreading the disorder in any street, public place, or enters any public conveyance without previously notifying to the owner, conductor, or driver thereof that he is suffering; or,
2. Being in charge of any person so suffering, so exposes such sufferer; or,
3. Gives, lends, sells, transmits, or exposes, without previous disinfection, any bedding, clothing, rags, or other things which have been exposed to infection from any such disorder;

shall be liable to a penalty not exceeding five pounds; and a person who, while suffering from any such disorder, enters any public conveyance without previously notifying to the owner or driver that he is so suffering, shall in addition be ordered by the Court to pay such owner and driver the amount of any loss or expense they may incur in carrying into effect the provisions of this Act with respect to disinfection of the conveyance.

Provided that no proceedings shall be taken against persons transmitting with proper precautions any bedding, clothing, rags, or other things, for the purpose of having the same disinfected. Every owner or driver of a public conveyance shall immediately provide for the disinfection of such conveyance after it has, to his knowledge, conveyed any person suffering from a dangerous infectious disorder; and if he fail to do so he shall be liable to a penalty not exceeding five pounds; but no such owner or driver shall be required to convey any person so suffering until he has been paid a sum sufficient to cover any loss or expense incurred by him in carrying into effect the provisions of the section. Any person who, knowingly, lets for hire any house, room, or part of a house, in which any person has been suffering from any dangerous infectious disorder, without having such house, room, or part of a house, and all articles liable to retain infection, disinfected to the satisfaction of a legally qualified medical practitioner, as testified by a certificate signed by him, shall be liable to a penalty not exceeding twenty pounds. For the purpose of this Section, the keeper of an inn shall be deemed to let for hire part of a house to any person admitted as a guest into such inn. Any person letting for hire, or showing for the purpose of letting for hire,

any house or part of a house, who, on being questioned by any person negotiating for the hire of such house, or part of a house, as to the fact of there being, or within six weeks previously having been, any person suffering from any dangerous infectious disorder, knowingly makes a false answer to such question, shall be liable, at the discretion of the Court, to a penalty not exceeding twenty pounds, or to imprisonment, with or without hard labour, for a period not exceeding one month.

MORTUARIES, ETC.

Any L. A. may, and if required by Local Government Board, shall provide and fit up a proper place for the reception of dead bodies before interment, and may make by-laws with respect to the management and charges for use of the same; they may also provide for the decent and economical interment of any dead body which may be received into a mortuary. Where the body of one who has died of any infectious disease is retained in a room in which persons live or sleep, or any dead body which is in such a state as to endanger the health of the inmates of the same house or room, is retained in such house or room, any Justice may, on a certificate signed by a *legally qualified medical practitioner*, order the body to be removed, at the cost of the L. A., to any mortuary provided by such L. A., and direct the same to be buried within a time to be limited in such order; and unless the friends and relations of the deceased undertake to bury the body within the time so limited, and do bury the same, it shall be the duty of the relieving officer to bury such body at the expense of the poor-rate, but any expense so incurred may be recovered by the relieving officer from any person legally liable to pay the expense of such burial. Any person obstructing the execution of an order made by a Justice under this Section, shall be liable to a penalty not exceeding five pounds. Any L. A. may provide and maintain a proper place (otherwise than at a workhouse or a mortuary) for the reception of dead bodies during the time required to conduct any *post-mortem* examination ordered by a coroner or other constituted authority, and may make regulations with respect to the management of such place; and where any such place has been provided, a coroner or other constituted authority may order the removal of the body to and from such place for carrying out such *post-mortem* examination, such costs of removal to be paid in the same manner and out of the same fund as the costs and fees for *post-mortem* examinations when ordered by the coroner.

HOSPITALS.

ACCOMMODATION FOR THE SICK.—This is provided for under Section 131 of the Public Health Act, 1875, by which the L.A. may build or lease a building for the purpose, or they may farm their sick in any hospital by paying for the reception of the same. Two or more L. A. may combine to provide a common hospital.

Hospitals should be built, if possible, on dry porous soil, well drained, with the wards facing south-east and north-west, and on the pavilion plan now so much advocated. This consists of a collection of small hospitals connected by corridors, the distance between the pavilions being about twice the height of the pavilions to allow of free circulation of air around each building. Mr Marshall has suggested circular wards for the following reasons, better supervision, warming and ventilation are easier, cleanliness is better secured and there is greater economy in management. There is, however, great waste of space in the centre of the ward. Hospitals with circular wards have been built at Greenwich, Antwerp, and elsewhere. All the sanitary arrangements should be as perfect as possible, the water-closets being placed as far as practicable outside the wards. The windows—one to every two beds—should be on each side of the ward to allow of cross ventilation, and should extend from 2 to 3 feet above the floor, to between 6 to 12 inches from the ceiling of the ward. The windows should be made so as to open at the top sash, or be provided with ventilators in one or more of the panes of glass. The corners of the ward should be rounded to prevent the collection of dust, etc. The unit of an hospital is the ward, and this should not contain more than thirty-two beds, the number fixed by Miss Nightingale as capable of being watched over by one head nurse. A ward to contain twenty patients should be 80 feet long, 25 feet wide, 14 feet high. If the ward be higher than the height given, ventilation is impeded. The temperature

of the ward should be about 60° F., and this is best maintained by the use of Galton's grates and hot water pipes. The products of combustion of gas jets should be removed by extraction flues over each jet. The floors are best made of hard wood polished. Each patient should be allowed at least 1600 cubic feet of space, and a superficial area of 100 square feet for each bed. For infectious diseases these numbers should be increased. The establishment of cottage hospitals in rural districts has been found of great advantage, one bed being provided for each 1000 persons in the district. The size of infectious hospitals will depend upon the population of the town, one bed being provided for every 1000 or 2000 of the population.

CONTAGION.

On this subject opinions have differed, and still continue to differ. For a full account of the present received opinions on this subject, the student is referred to the reports of the medical officer of the Privy Council. The earlier ideas that contagion consisted of inorganic solids, liquids, or even gaseous fluids in peculiar electrical states, which acted as "ferments" in the blood, have of late given place to the theory that contagion is due to the presence of small bodies either present in the air or floating about in a fluid, as, for instance, the vaccine lymph.

"It is characteristic," says Dr Burdon Sanderson (Twelfth Report of the Medical Officer of the Privy Council), "of many of the communicable diseases, that at the same period, in the course of their development, liquids exist in the diseased body, whether human or animal, which have the power of producing the original disorder when brought into contact with the living substance of a healthy individual. Such liquids are said to be virulent or infecting. Their occurrence in

human pathology is familiar to us in small-pox and syphilis; and lately we have learned experimentally to recognise it in tuberculosis, and inferentially in other allied diseases. Among the lower animals, the maladies of which the liquid contagium is known, are much more numerous. In some, as in cattle plague and in anthrax, all the tissues and juices become virulent; in others, the contagious property is found only in liquids derived from special seats of diseased processes similar to ordinary inflammation, as, *e.g.*, in glanders, in pleuro-pneumonia, and in sheep-pox."

In 1868, M. Chauveau published two papers, in which he showed that when vaccine lymph was mixed with water in varying proportions, and allowed to settle for twenty-four hours, vaccine pustules were not produced when the upper portions of the fluid were used, and that the amount of successful results increased as the lower portions were used. It has also been found that vaccine lymph, examined under the microscope, contains certain small bodies, to which the infecting properties of the lymph are attributed; but "it is not contended that all varieties of contagion are liquid, or dissolved, or suspended in liquid, but only that the several contagia of diseases known to be inoculable must be contained in the liquids with which we can perform inoculation."

Dr Parkes collects the several views on the nature of contagion under three heads, to which we will add three more:—

1. That the particles are supposed to be of animal origin, born in, and only growing in the body; they are, in fact, minute portions of bioplasm (Beale) or protoplasm.

The meaning of this term "bioplasm," is thus given by Beale:—"The term I propose to apply to the living germinal, self-propagating matter of living beings, and to restrict to this, is bioplasm (Βιος, life; and πλάσμα, plasm). Now that the word biology has

come into common use, it seems desirable to employ the same root in speaking of the matter which it is the main purpose of biology to investigate. Bioplasm involves no theory as regards the nature or the origin of the matter; it simply distinguishes it as living." ("Disease Germs; their Nature and Origin," 1872.) A "germ" is, according to this writer, "a particle of living matter which has been detached from already existing living matter, and this living matter came from matter of some sort which lived before it."

This doctrine, as Parkes pointed out, is the scientific dress for the old doctrine of "fomites." These particles are said to possess an independent life, are capable of moving about in the fluids, searching for food, growing, and dying. The failure of the transference of disease from one individual to another may be explained, on this theory, to the want of the proper supply of food in the second individual; or the recurrence of the same disease, to the fact that all the necessary amount of nutriment has been used up during the first attack. Against this is the fact that living animals, when removed from the body, rapidly die; but this is not the case with these particles, which appear to possess considerable vitality.

2. The particles are supposed to be of a fungoid nature, and to simply grow in the body after being introduced *ab externo.* In other words, that contagium is not merely in the sense of being part of a living body, as in the case of a blood cell, but it is a distinct living organised being, living within a diseased body, and capable of propagating itself. This doctrine has been ably supported by Professor Hallier, who contends that the contagium particles of cholera, diarrhœa, small-pox, syphilis, etc., are of a fungoid nature.

Of this theory Dr Parkes remarks:—"It is clearly a view which would explain many phenomena of the contagious diseases, and has been supported by the experimental evidence of Hallier and many others

who have believed that they have invariably indentified special fungi from particles of contagia. At the present time, however, the evidence of true and recognisable and special fungi being thus discovered and grown, and forming the efficient causes, is very much doubted by the best observers. These doubts of recent years have been set at rest."

3. The particles of contagia are thought to be like "schizomycetæ," *i.e.*, of that class of organisms which, according to Nägeli, are not fungi, but partake somewhat of the character of bacteria, with which they are probably identical. These bodies have been called bacteria, vibrios, monads, microzymes, zoöglœa. They have been shown by Klebs and Recklinghausen to play an important part in the production of septicæmia, and, according to Parkes, "they have been proved to cause disease of the intestinal mucous membrane, the uterus, the kidneys, and the heart." Dr Burdon Sanderson states that, under certain favourable conditions, "a single bacterium will produce 16,777,220 individuals every twenty-four hours." To determine the connection of any microbe with disease, Koch has formulated the following conditions :—

1. The microbe must be found in the body of the man or animal, suffering from, or who has died of the disease.
2. The microbe must be isolated and cultivated in suitable media outside the body of the animal. The cultivations should be carried on through successive generations of the organism in order to secure its purity.
3. A pure cultivation when introduced into the body of a suitable healthy animal, must produce the disease in question.
4. In the inoculated animal the same microbe must again be found.

As yet the above conditions have only been fulfilled in anthrax, relapsing fever, pyæmia, and erysipelas. The great difficulty is of course to satisfy the third requirements of Koch.*

* For the life history, cultivation, etc., of bacteria, the student is referred to J. R. Whitaker's "Notes on Pathology," a most useful little book.

4. The theory of Dr A. E. Sanson, is best expressed in his own words:—"The poisons of spreading diseases are extremely minute living organisms, having the characteristic endowments of vegetable growths, analogous to the minute particles of vegetable protoplasm, whose function it is to disintegrate and convert complex organic products, owing their specific properties in the special diseases not to any botanical peculiarities but to the characters implanted in them by the soil in which they first sprang from innocuous plants, and from which they are transmitted; this soil (except in the case of their earliest origin) being the fluids of the animal bodies." ("The Antiseptic System.")

5. The "graft theory" of Dr James Ross, based on Darwin's theory of pangenesis, and applied to explain the phenomena of zymotic diseases. "Heterologous growth" or modified portions of the individual from whom they have become detached, and which produce disease when "grafted" into another person.

6. The purely "physical theory" of Sir W. B. Richardson, that certain substances exert their deleterious properties, by setting at liberty the oxygen of the blood in undue quantities, the organic substances during the process becoming themselves decomposed.

These organic poisons, it is also stated, are capable of forming salts with acids.

How is Contagium Communicated?—Both directly and indirectly—directly as in vaccination, gonorrhœa, syphilis, etc.; and indirectly when there is some intervening media, as water, air, food, etc. The following experiment was performed by Küchenmeister:—A sheep was made to breathe for an hour air passed through a shirt worn for some hours by a small-pox patient. Five days afterwards small-pox commenced in the sheep, and on the eighth day a well-marked eruption was developed. The outbreaks of typhoid in

Islington and Marylebone were clearly traced to the milk used by those attacked.

On what Conditions does the Life or Activity of Contagia Depend? — On this subject very little is positively known. Of the effect of cold, Dr Braidwood states that the exposure of vaccine lymph for an hour and a quarter to a temperature nearly a hundred degrees below that at which mercury solidifies, not only does not destroy the activity of vaccine lymph, but does not impair or affect it at all—that is, so far as regards its specific properties. Heat also, according to the experiments of the same writer, has, contrary to the generally received opinion that 140° F. destroyed the potency of vaccine, no effect on vaccine, unless the temperature be raised to 149½° F.

DISINFECTANTS AND DEODORANTS.

These terms are often used indiscriminately, but the latter simply act by disguising the smell, whilst there is good reason to believe that the former actually destroy the disease germs. Eau de Cologne is an example of the class deodorants, and Condy's Fluid of the class disinfectants.

The following remarks are an epitome of the article on disinfectants by Dr Baxter, in the Reports of the Medical Officer of the Privy Council, 1875. The term disinfectant is still employed to designate agents possessing one or more of the following properties :—

1. That of checking or preventing certain chemical changes due to the operation of azotised ferments, and seemingly independent of the presence of living organisms. The word "catalysis" is used to specify, without in any way elucidating, the nature of such changes. Examples of them are furnished by the action of emulsin upon amygdalin, or diastase on starch, etc.

2. That of preventing or stopping decompositions, which are casually connected with the presence of organisms. Looked at

from the biological rather than the chemical point of view, such changes naturally fall under at least two heads—viz, *fermentations*, occurring in acid media, and attended with the germination and multiplication of torula forms; and *putrefactions*, occurring in neutral or alkaline media, and associated with the presence and vital activity of schizomycetous organisms.

3. That of destroying the injurious products of any of the above processes, or of rendering them innocuous to man and the higher animals.

4. That of destroying the contagia of communicable diseases, or of depriving such contagia of their specific infective power.

The late Dr Parkes gave the following as the best definition of the term "disinfectants":—"Those substances which can prevent infectious diseases from spreading, by destroying their specific poisons;" and these must be carefully distinguished from "those agents which merely arrest the progress or absorb the offensive products of organic decomposition."

Dr Baxter defines a "disinfectant" to be "any agent capable of so modifying the contagium of a communicable disease, during its transit from a sick to a healthy individual, as to deprive it of its specific power of infecting the latter."

Reasons for the discordance of opinion on the meaning of the term "disinfectant":—

1. Ignorance of the nature of contagion.

2. Ignorance of the power of any agent in destroying the specific virus, due to the difficulty in carrying out the necessary precautions, and watching results.

3. Preconceived notions of individuals as to the pathological nature of contagium. Germ theory, molecular change in albuminoid principles, etc. etc.

DISINFECTANTS AND ANTISEPTICS.

The term *antiseptic* is generally applied to any subtance which prevents the *origin* of a disease—*disinfectant* to any substance which prevents the *future spread* of a disease after it has begun. Antiseptics may act by

oxidising the ferment directly—*e.g.*, permanganate of potash, indirectly—*e.g.*, chlorine and water; by chemical affinity as in the combination of carbolic acid with albumen, thus killing the micro-organisms which are protoplasmic bodies; and lastly the antiseptic may have a direct toxic action—corrosive sublimate, quinine etc.

Dr Baxter, from the experiments performed by him has arrived at the following conclusions:—

1. That carbolic acid, sulphur dioxide, potassic permanganate, and chlorine, are all of them endowed with true disinfectant properties, though in various degrees.

2. It is essential to bear in mind that antiseptic is not synonymous with disinfectant power, though as regards the four agents enumerated above, the one is, in a certain limited sense, commensurate with the other.

3. The value of chlorine and potassic permanganate appears to depend more on the nature of the medium through which the particles of infective matter are distributed, than on the specific characters of the particles themselves.

4. When either of these agents is used to disinfect a virulent liquid containing much organic matter, or any compounds capable of uniting with chlorine, or of decomposing the permanganate, there is no security for the effectual fulfilment of disinfection short of the presence of free chlorine or undecomposed permanganate in the liquid after all chemical action has had time to subside.

5. A virulent liquid cannot be regarded as certainly and completely disinfected by sulphur dioxide unless it has been rendered permanently and strongly acid. The greater solubility of this agent renders it preferable, *cæteris paribus*, to chlorine and carbolic acid for the disinfection of liquid media.

6. No virulent liquid can be considered disinfected by carbolic acid unless it contain at least two per cent. by weight of pure acid.

7. When disinfectants are mixed with a liquid, it is important to be sure that they are thoroughly incorporated with it, that no solid matters capable of shielding contagium from immediate contact with its destroyer be overlooked.

8. Aerial disinfection, as commonly practised in the sickroom, is either useless or positively objectionable, owing to the false sense of security it is calculated to produce. To make the air of a room smell strongly of carbolic acid, by scattering carbolic acid powder about the floor, or of chlorine, by placing a tray of chloride of lime in a corner, is, so far as the destruction of specific contagia is concerned, an utterly futile proceeding.

9. When aerial disinfection is used, chlorine and sulphur dioxide are, both of them, suitable agents; the latter being the more effectual of the two. The place should be kept saturated by the gas for at least an hour, and longer if possible.

10. It is probable that all contagia disappear sooner or later under the influence of air and moisture, and that the absence of these influences may act as a preservative.

11. Dry heat, when it can be applied, is probably the most efficient of all disinfectants, care being taken that a sufficiently high temperature be maintained, that every portion of the article be subjected to the same temperature, and that the exposure to heat be prolonged for some time. A temperature of about 250° F. can be borne, without scorching, by most articles of dress.

NOTE.—Boiling water is perhaps as good or even a better disinfectant than dry heat. Super-heated steam under pressure has been lately suggested and advocated by Dr H. F. Parsons. It has a greater penetrating power than hot air.

To these may be added, the following from the Memorandum on Disinfection, issued by the Medical Officer to the Privy Council, 1866:—

"It is to cleanliness, ventilation, and drainage, and the use of perfectly pure drinking water, that populations ought mainly to look for safety against nuisance and infection. Artificial disinfectants cannot properly supply the place of these essentials; for, except in a small and peculiar class of cases, they are of temporary and imperfect usefulness."

SCHOOLS, CHURCHES, AND THEATRES.

In schools, churches, and theatres, a system of thorough ventilation is absolutely necessary; and in the case of theatres, care should be taken that the means of egress in case of fire is easy of access.

A proposal for ventilating the school-rooms of Boston has been presented to the Massachussetts State Board of Health by Mr Martin, architect, by means of a ventilating shaft—the impure air being removed from the room through openings under the scholars—fresh air, properly warmed, being admitted from the roof. Mr Martin refers the injurious effect of bad

ventilation, not so much to the carbonic acid present in the air, as to "the watery vapour and the animal matter thrown off both by lungs and skin, which seems to putrefy almost immediately after being thrown into the air."

LIGHTING.—The window area has been stated to be from one-fourth to one-tenth of the floor area, or the square root of the length, breadth, and height multiplied together. The light should never enter in front of the scholars, nor from the back if possible, as it causes the scholar to sit in a twisted position to keep his book out of shade. The best light is that provided from the left, and the height of the sills of the windows should never be less than five feet from the floor. Lighting from both sides may be allowed if the room be very large, and the light from the left side be the stronger.

DESKS.—Besides the questions of lighting, ventilation, etc., there are other sanitary matters connected with schools that demand a brief notice. Eulenberg states that 90 per cent. of curvatures of the spine, not caused by actual bone disease, are developed during school life. A flat desk is bad, necessitating a cramped position interfering with free respiration; and a desk too far from the seat has a tendency to cause a forward stoop, flat chest, round shoulders, and injury to the eyes. The slope of the desk should be capable of change—for writing, an angle of 30° should be adopted, and one from 40° to 45° for reading.

SEATS.—These should be adapted to the height of the scholars. If too high, the feet swing and the vessels and nerves at the back of the legs are compressed, especially if the seat is too narrow. If the seat be too low, the thighs are bent up to the body. The *height* of the seat should be equal to the length of the leg from the sole of the foot to the knee, and its *width* not less than eight inches. Backs should be

provided to each seat. Liebriech states that the top of the back of the seat should be an inch lower than the edge of the desk for boys, and an inch higher than the same point for girls. The distance between the seat and top of the desk should be the length of the forearm, or one-sixth the height of the scholar. The edge of the seat should be directly under the edge of the desk, or at least not more than an inch should intervene between the points above stated.

The Law with regard to Schools during Epidemics.—Schools may be closed by order of the Local Authority during the prevalence of epidemics, and in such cases a proportionate reduction is made from the number of meetings required to qualify for the Parliamentary grant. The managers may appeal to the Educational Department if they consider the closing of the school by the Local Authority unreasonable.

Sunday schools, "dames," or private schools, are not subject to the authority of the Local Authority, unless they contravene sections 91 to 126 of the Public Health Act, 1875.

CEMETERIES.

The disposal of the dead is a matter of considerable importance to the well-being of a community. The following methods have been adopted:—(1) Embalming, (2) Cremation, (3) Sea-burial, and (4) Land-burial.

Cremation, in a sanitary point of view, is by far the best way of disposing of the dead, but public prejudice is against the proceeding. Sir Henry Thompson sometime ago drew attention to this subject in an article on "Cremation" in the "Contemporary Review;" but his advocacy was marred by his commercial views as to the value of the dust for agricultural purposes, at once disgusting and repulsive to most people.

Sea-burial can only be adopted in towns on the coast, as the expense would be too great when the body has to be carried any distance. *Embalming* is never likely to be adopted by modern nations.

Land-burial, which, in a sanitary point of view, is the worst of all forms of burial, will most probably last the longest of any, till the public mind by degrees becomes tutored to an enlightened appreciation of the sanitary benefits of cremation.

Burial in the ground is open to the following objections:—

(*a*) That the air over churchyards and cemeteries is charged with carbonic acid, ammonia, and an offensive putrid vapour. From the churchyards of London it has been stated that 2½ millions of cubic feet of carbonic acid gas were given off yearly by 52,000 bodies buried in the yards.

(*b*) That disturbance of these grounds gives rise to disease.

(*c*) That wells and other sources of water supply are contaminated by impurities percolating through the soil.

The following remedies have been suggested:—

(*a*) The removal of burying-grounds to some distance beyond the town.

(*b*) Burying the body as deeply as possible, and only one body in each grave. This rule is broken daily in the cemeteries round London: four or five bodies in the same grave is not unusual.

(*c*) The use of plants of quick growth and dense foliage, which purify the air by absorbing the organic substances and the carbonic acid.

(*d*) Careful selection of the site and soil. In selecting a site for a cemetery, a declivity facing the north or north-east is to be preferred. The drainage of the soil is thus facilitated. The soil, if selection is permitted, should be dry and well drained, care being taken that the drainage does not have access to any stream or well from which water is drawn for domestic purposes. A porous, coarse-grained, gravelly soil should be selected, stiff clay or marly soils rejected, for the future site of a cemetery. All soils containing much water should be extensively under-drained. No body should be buried at a less depth than six feet from the surface, and the more perishable the coffin the better. Houses should not be nearer the walls of a cemetery than 500 yards—a rule seldom kept, for near London the site of a cemetery seems to have an attraction

for the builders of "suburban villas." In calculating the area required for a town, take the death-rate at 30 per 1000, and allow two square yards for each grave, that is, for the grave and space between it and the next. Another method of calculation is to allow a quarter of an acre of burial space to each 1000 head of population. This is, however, not enough where the soil is unfavourable, and extensive pathways are allowed. The space given above may with advantage be increased by 50 per cent., or say half an acre per 1000.

The following are the regulations issued by the Home Office in 1863 under the Burial Acts.

The grave spaces for persons above 12 years of age shall be at least 9 feet by 4 feet (4 square yards): under 12 years of age 6 feet by 3 feet or $4\frac{1}{2}$ feet by 4 feet (2 square yards). There must be at least a foot between each grave.

No unwalled grave shall be re-opened within fourteen years after the burial of a person above 12 years of age, or within eight years under 12, unless to bury another member of the same family, in which case a layer of earth not less than 1 foot thick shall be left undisturbed above the previously buried coffin.

No coffin shall be buried in any unwalled grave within 4 feet of the surface of the ground, unless it contains the body of a child under 12 years of age, when it shall not be less than 3 feet below the level.

QUARANTINE ESTABLISHMENTS.

These establishments were first appointed by the Venetians, the regulations being made about the year 1484.

The term is derived from the Italian *quaranta*, forty; forty days or six weeks being the time supposed to be required by those on board a ship sailing from an infected port to purify themselves and their baggage.

The first regulations were instituted against the importation of the plague, which was generally supposed to have been introduced into Western Europe from the East. Most other countries have adopted more or less entirely the Venetian practice of detaining travellers from entering their country unless they can show a clean bill of health.

The existing Quarantine Regulations are embodied in the 6 Geo. IV., c. 78, and the different orders of the Local Government Board issued under its authority. All orders of the Board with regard to quarantine are published in the "Gazette;" and this publication is deemed sufficient notice to all concerned, and no excuse of ignorance is admitted for any infringement of the regulations. All vessels are furnished with an abstract of the Quarantine Regulations, of which the following is an epitome, dated July 1873:—

DEFINITIONS.

Art. 1. In this Order—

The term "Ship" includes vessel or boat.

The term "Officer of Customs" includes any person having authority from the Commissioners of Customs.

The term "Master" includes the officer or person for the time being in charge or command of a ship.

The term "Cholera" includes Choleraic Diarrhœa.

The term "Sanitary Authority" has the same meaning as in "The Public Health Act, 1872," now 1875.

The term "Clothing and Bedding" includes all clothing and bedding in actual use, and worn or used by the person attacked, at the time or during the attack of cholera.

For the purposes of this Order, every ship shall be deemed infected with cholera, in which there is or has been, during the voyage or during the stay of such ship in any foreign part in the course of such voyage, any case of cholera.

1. Regulations as to Customs Inspections.

Art. 2. Custom House may detain ship on suspicion, at a certain place appointed.

Art. 3. No one must leave ship so detained.

Art. 4. Notice must be at once sent to "Port Sanitary Authority," or "Sanitary Authority of district," in which the ship is detained.

Art 5. Detention shall cease as soon as visited by Sanitary Authority, if found free of disease; if not, must be removed to place appointed by Sanitary Authority;

Provided that, if the examination be not commenced within twelve hours after notice, the ship shall, on the expiration of twelve hours, be released from detention.

2. Regulations as to Sanitary Authorities.

Art. 1. Sanitary Authority, with the approval of Chief Officer of Customs, to fix place where vessel shall be detained.

Art. 2. Officer appointed by Sanitary Authority shall visit and examine ship, and Master must permit same.

Art. 3. Medical Officer of Sanitary Authority, or other qualified Medical Practitioner appointed by Sanitary Authority, to visit ship and report.

Art. 9. Master of ship must moor or anchor ship during the pleasure of Sanitary Authority, and at the place appointed by such authority.

Art. 10. No person must leave ship till after examination and permission.

Art. 11. On report of Medical Officer or Medical Practitioner, persons may land on conditions hereinafter mentioned.

Art. 12. Those suffering from cholera may be removed to hospital, if capable of being removed, and there detained till certified by Medical Officer or Medical Practitioner. If they cannot be removed they must remain, subject to certificate of Medical Officer, as if in hospital.

Art. 13. Measures to be taken to prevent spread of disease, and Master must assist in the same.

Art. 14. Any one suffering from any diarrhœal or other illness, may be detained in ship or sent to hospital, for any period not exceeding two days, until it is ascertained whether the illness is or is not cholera. If then suffering from cholera, to be detained as aforesaid.

Art. 15. Any death on board, body must be properly weighted and committed to the deep.

Art. 16. Master must disinfect clothing, etc., under the superintendence of Sanitary Authority.

Art. 17. The Master must cause ship to be disinfected, and if necessary destroy articles infected, by order of Sanitary Authority or Medical Officer.

The following are the Regulations made by the Local Government Board, in accordance with the requirements of the Canal Boats Act, 1877 (40 and 41 Vict., c. 60).

For fixing the number, age, and sex of the persons who may be allowed to dwell in a canal boat, having

regard to the cubic space, ventilation, provision for the separation of the sexes, general healthiness and convenience of accommodation of the boat.

8. For the above purpose the following Rules shall apply :—

(*a*) In the cabin or cabins of the boat there shall be not less than 60 cubic feet or free air space for each person above the age of twelve years, and not less than 40 cubic feet of free air space for each child under the age of twelve years.

Boats built prior to 30th of June 1878, the free air space for each child under the age of twelve years, may be not less than 30 cubic feet.

In the case of a "fly" boat, worked by four persons above the age of twelve years, there shall be not less than 180 cubic feet of free air space in any cabin occupied as a sleeping-place by any two of such persons at the same time.

(*b*) A cabin occupied as a sleeping-place by a husband and wife shall not, while in such occupation, be occupied as a sleeping-place by any other person of the female sex above the age of twelve years, or by any other person of the male sex above the age of fourteen years.

In the case of a boat built prior to the 30th June 1878, a cabin, occupied as a sleeping-place by a husband and wife, may be occupied by one other person of the male sex above the age of fourteen years, subject to the following conditions :—

1. That the cabin be not occupied as a sleeping-place by any other person than those above mentioned ; and
2. That the part of the cabin which may be used as a sleeping-place by the husband and wife shall, at all times while in actual use be effectually separated from the part used as a sleeping-place by the other occupant of the cabin, by means of a sliding or otherwise moveable screen or partition of wood or other solid material, so constructed or placed as to provide for efficient ventilation.

(*c*) A cabin occupied as a sleeping-place by a person of the male sex above the age of fourteen years, shall not, at any time, be occupied as a sleeping-place by a person of the female sex above the age of twelve years, unless she be the wife of the male occupant, or of one of the male occupants, in any case within the proviso to Rule (*b*).

LOCAL GOVERNMENT BOARD.

The Local Government Board was constituted in 1871 and superseded the Poor Law Board. It is composed as follows :—A paid President appointed by Her Majesty, all the principal Secretaries of State, the Lord Privy Seal and the Chancellor of the Exchequer, and a Parliamentary and a permanent Secretary. Attached to it are a Medical Officer, and several medical, legal, and scientific Inspectors. It is the Central Authority, and is the Court of Appeal from all Local Authorities, and can be addressed by memorials from all parts of the country. The Board takes charge of the registration of births, deaths, and marriages, and of all matters that appertain to the public health, such as drainage, the prevention and arrest of epidemics, the improvement of towns; and on it also rests the powers formerly exercised by the Board of Trade with regard to the enforcement of the provisions of Alkali Acts. By Provisional Order it can make or unmake Sanitary Districts. These Provisional Orders are of no force till confirmed by Parliament, when they become virtually Acts of Parliament. They are granted by the Local Government Board on petition by the Local Authority, are introduced into a Bill, and, if not opposed, are carried through both Houses by the Local Government Board. If opposed, they become subject to all the vicissitudes of a private bill. The Board can take the initiative in sanitation, and can appoint Medical Officers to visit and report on the condition of any place, if necessary; and also controls the salaries of Medical Officers of Health, when any part of the salary is paid by the Crown. Most of the Medical Officers of Health are, however, paid solely by the Local Authorities, who have then the power of controlling the salary, engagement, and dismissal of the Medical Officer.

LOCAL AUTHORITIES. — For sanitary purposes, in England the country is divided into Urban and Rural Sanitary Authorities. The Town Council, Improvement Commissioners, and Local Board for the one—and the Union for the other,—are the Local Authorities of their respective districts. According to the Public Health (Scotland) Act, 30 and 31 Vict., c. 101, the following bodies shall respectively be the Local Authority to execute this Act:—

In places within the jurisdiction of any Town Council, and not subject to the jurisdiction of Police Commissioners or Trustees, as after mentioned—the Town Council.

In places within the jurisdiction of Police Commissioners under any General or Local Act—the Police Commissioners.

In any parish or part thereof, over which the jurisdiction of a Town Council, or of Police Commissioners, or Trustees exercising the functions of Police Commissioners, does not extend — the Parochial Board of such parish.

MEDICAL OFFICERS OF HEALTH.

These are appointed by the Local Authority for a term of years. They are not prevented from private practice, unless such be agreed upon at date of appointment. Any duly qualified medical practitioner may be appointed, provided he holds a degree or licence in Sanitary Science.

DUTIES OF A MEDICAL OFFICER OF HEALTH.

The following shall be the duties of the Medical Officer of Health in respect of the Sanitary district for which he is appointed; or if he shall be appointed for more than one district, or for a part of a district, then in respect of each of such districts or of such part:—

1. He shall inform himself, as far as practicable, respecting all influences affecting, or threatening to affect, injuriously the public health within the district.

2. He shall inquire into and ascertain, by such means as are at his disposal, the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

4. He shall be prepared to advise the Sanitary Authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the Sanitary Authority or Authorities; and, in cases requiring it, he shall certify, for the guidance of the Sanitary Authority or of the Justices, as to any matter in respect of which the certificate of a Medical Officer of Health or a medical practitioner is required as the basis, or in aid of, sanitary action.

5. He shall advise the Sanitary Authority on any question relating to health involved in the framing and subsequent working of such by-laws and regulations as they may have power to make.

6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay, and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

7. On receiving information from the Inspector of Nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps, authorised by the Statutes in that behalf, as the circumstances of the case may justify and require.

8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the Sanitary Authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale, or deposited for the purpose of sale or preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man, and if he find that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken and carried away, in order to be dealt with by a Justice according to the provisions of the Statutes applicable to the case. This regulation is confirmed by the Public Health Act, 1875. See also Public Health (Scotland) Act, 1867, Public Health (Ireland) Act, 1874.

9. He shall perform all the duties imposed upon him by any by-laws and regulations of the Sanitary Authority, duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame by-laws and regulations.

10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

11. He shall attend at the office of the Sanitary Authority, or at some other appointed place, at such stated times as they may direct.

12. He shall, from time to time report, in writing, to the Sanitary Authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

13. He shall keep a book or books, to be provided by the Sanitary Authority, in which be shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and result of the action taken thereon, and of any action taken on previous reports, and shall produce such book or books, whenever required, to the Sanitary Authority.

14. He shall also prepare an Annual Report, to be made at the end of December in each year, comprising tabular statements of the sickness and mortality within the district, classified according to diseases, ages, and localities, and a summary of the action taken during the year for preventing the spread of disease. The report shall also contain an account of the proceedings in which he has taken part, or advised, under the Sanitary Acts, so far as such proceedings relate to conditions dangerous or injurious to health, and also on account of the supervision exercised by him, or on his advice, for sanitary purposes, over places and houses that the Sanitary Authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same, during the year. It shall also record the action taken by him or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special report.

16. In matters not specially provided for in this Order, he shall observe and execute the instructions of the Local Government Board on the duties of Medical Officers of Health, and all the lawful orders and directions of the Sanitary Authority applicable to his office.

17. Whenever the Diseases Prevention Act of 1855 is in force within the district, he shall observe the directions and regulations issued under that Act by the Local Government Board, so far as the same relate to or concern his office.

INSPECTOR OF NUISANCES.

Any intelligent artisan may hold the appointment. He is seldom required to take the initiative in sanitation, but by virtue of his office can do so when cleaning is indicated.

DUTIES OF INSPECTORS OF NUISANCES.

The following shall be the duties of the Inspector of Nuisances, as laid down by an Order of the Local Government Board, March 1880, in respect of the district for which he is appointed, or if he shall be appointed for more than one district, then in respect of each of such districts :—

1. He shall perform, either under the special directions of the Sanitary Authority, or (so far as authorised by the Sanitary Authority) under the directions of the Medical Officer of Health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an Inspector of Nuisances by the Sanitary Acts, or by the Orders of the Local Government Board.

2. He shall attend all meetings of the Sanitary Authority when so required.

3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement under the Sanitary Acts.

4. On receiving notice of the existence of any nuisance within the district, or of the breach of any by-laws or regulations made by the Sanitary Authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of by-laws or regulations.

5. He shall report to the Sanitary Authority any noxious or offensive business, trades, or manufactories established within the district, and the breach or non-observance of any by-laws or regulations made in respect of the same.

6. He shall report to the Sanitary Authority any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

7. He shall, from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, or flour, or as a slaughter-house, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, which may be therein ; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized ; and take such other proceedings as may be necessary in order to have the same dealt with by a Justice : Provided that in any case of doubt arising under this clause, he shall report the matter to the Medical Officer of Health, with the view of obtaining his advice thereon.

8. He shall, when and as directed by the Sanitary Authority, procure and submit samples of food or drink, and drugs suspected

to be adulterated, to be analysed by the analyst appointed under the Adulteration of Food Act, 1872; and upon receiving a certificate stating that the articles of food or drink, or drugs, are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

9. He shall give immediate notice to the Medical Officer of Health of the occurrence within his district of any contagious, infectious, or epidemic disease of a dangerous character; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the Medical Officer thereof.

10. He shall, subject in all respects to the directions of the Sanitary Authority, attend to the instructions of the Medical Officer of Health with respect to any measures which can be lawfully taken by him under the Sanitary Acts for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

11. He shall enter, from day to day, in a book to be provided by the Sanitary Authority, particulars of his inspections, and the action taken by him in the execution of his duties. He shall also keep a book, or books, to be provided by the Sanitary Authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the Sanitary Act, and shall keep any other systematic records that the Sanitary Authority may require.

12. He shall, at all reasonable times, when applied to by the Medical Officer of Health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of Inspector of Nuisances relate.

13. He shall, if directed by the Sanitary Authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

14. In matters not specifically provided for in this Order, he shall observe and execute all the lawful orders and directions of the Sanitary Authority, and the orders of the Local Government Board which may be hereafter issued applicable to his office.

NUISANCES.—A nuisance at common law is "anything which worketh hurt, inconvenience, or damage to any one." Under the Public Health Act, 1875, the term is confined to those matters which are injurious to health.

APPENDIX.

Some facts of interest to the student are here inserted :—

TO FIND THE CIRCUMFERENCE OF A CIRCLE.

$$D \times 3{\cdot}1416.$$

TO CALCULATE THE REQUIRED THICKNESS OF A PIPE.

Multiply the pressure in pounds per square inch by the diameter of the pipe in inches, and divide the product by twice the tensile resistance of a square inch of the material of which the pipe is constructed.

PRESSURE ON THE SIDES OF VESSELS.

The side of any vessel sustains a pressure equal to its area multiplied by half the depth of the fluid, and the whole pressure upon the bottom and against the sides of a vessel is equal to three times the weight of the fluid. See page 596 for example.

PRESSURE ON THE BOTTOM OF A CONICAL, PYRAMIDAL, OR CYLINDRICAL VESSEL.

The pressure is equal to the area of the bottom and depth of the fluid.

THE STORAGE OF WATER.

$$D = \frac{1000}{\sqrt{F}}$$

D = number of days supply to be stored.
F = mean rainfall in inches for three consecutive dry years.

TO FIND THE SPECIFIC GRAVITY OF ANY SOLID OR FLUID.

Divide the weight in pounds avoirdupois of a cubic foot of the body, whatever it may be, by 62·32, the weight in pounds avoirdupois of a cubic foot of distilled water, and the quotient obtained will be the specific gravity of the body.

TO FIND THE WEIGHT OF A CUBIC FOOT OF ANY SOLID OR LIQUID.

Multiply the specific gravity of the body by 62·32, and the result obtained will be the weight of a cubic foot of the body in pounds avoirdupois.

BRICK AND IRON STOVES.

Brick, although a worse conductor of heat than iron, yet parts with heat from its surface more readily than the latter material. Owing to its slow conductibility, it warms the air more equably than iron; at the same time it does not allow of the passage of obnoxious gases generated during perfect or partial combustion. Iron stoves, allowed to get red hot, transmit carbonic oxide from the fire, or even manufacture it from the carbonic acid in the air.

FLOUR.

The cold aqueous extract of flour, is obtained by digesting 10 grammes of flour in 500 c.c. of water, filtering, and evaporating down to 250 c.c. One hundred grammes of flour yield to water—

	Grammes.
Sugar, gum, dextrine	3·33
Vegetable Albumin	0·92
Phosphate of Potash	0·44
	4·69

On ignition the ash should consist entirely of phosphate of potash, from which the phosphoric acid may

be estimated. The sugar may be estimated in the usual way from the residue before ignition, but the determination of the weights of the cold extract, and the ash is as a rule sufficient.

BREAD.

The amount of water in bread may be determined by carefully drying 25 grains of bread till they cease to lose weight. Forty-two per cent. of moisture is allowed.

COWS' MILK.

The milk first drawn from a cow ("fore" milk) contains but little fat; the latter portions ("strippings") contain an excess. It consists of water, sugar, milk fats, caseine, salts, and extractive matters. Average sp. gr 1032. The total solids are obtained by evaporating to dryness a known quantity of the milk; the solids not fat is that portion left after the fats have been dissolved out with ether. The salts are obtained by incinerating the total solids and weighing. The average per centage of the "solids not fat" is from 9·3 to 9·5; the Society of Public Analysts takes 8·5 as the minimum; the "fats" should at least be equal to 2·5 per cent.

BUTTER.

Samples of Genuine Butter—Fatty acids.

Soluble,	5·92	5·76	4·77	per cent.
Insoluble,	87·86	88·10	88·44	
	93·78	93·86	93·21	

Adulterated Butter.

Soluble,	1·98	2·34	0·58	
Insoluble,	93·30	93·82	95·51	(Butterine).
	95·28	96·16	96·09	

(BLYTH).

Butter containing crystals is probably adulterated.

The caseine should average about 2·5 per cent., but it may amount to 6 or 7 per cent.

The specific gravity should not be below ·91101; and the melting point about 35·8° C. Any degree below this points to butterine or margarine, 31·3° C.; above, to other fats, tallow, 53·3° C.

BUTTERINE OR OLEO-MARGARINE.

This is prepared from beef fat by melting the fat and then straining it through cotton cloths, by which means the stearin is separated from the oleo-margarine. The oleo-margarine is now churned with milk to give it a flavour, coloured with annatto, rolled with ice, and made into "pats," or put into kegs, and exported.

MARGARINE ACT, 50 and 51 Vict., c. 29.

This Act came into force on 1st January 1888.

"Butter" is defined as "the substance usually known as butter, made exclusively from milk or cream, or both, with or without salt or other preservative, and with or without the addition of colouring matter;" and "Margarine," as "all substances, whether compounds or otherwise, prepared in imitation of butter, and mixed with butter, or not." No such substance shall be lawfully sold, "except under the name of Margarine, and under the conditions set forth in this Act." Every package, open or closed, is to be branded or durably marked "Margarine," on top, bottom, and sides, in printed letters, not less than three-quarters of an inch square. The marking must be clearly visible to the purchaser, and the wrapper must have the word "Margarine" in printed capitals, a quarter of an inch square. Samples may be procured by any Officer of Her Majesty's Customs or Inland Revenue, or any Medical Officer of Health, or Inspector of Nuisances, or Police

Constable, authorised under section 13 of the Sale of Foods and Drugs Act. All manufactories of Margarine in the United Kingdom must be registered by the Local Authority. Inspectors may take for analysis samples of butter suspected of being Margarine, and any substance not marked "Margarine" will be presumed to be exposed for sale as butter. For the first offence, a fine not exceeding £20; for the second, not exceeding £50; and for the third, not exceeding £100. An employer is to be exempt from penalties, if he can prove that the offence has been committed by some other person without his knowledge or concurrence. The real offender is, however, to be punished. The onus of carrying out the Act is thrown on the Local Authorities.

BY-LAWS.

By-Laws are the Regulations made by Local Authorities with regard to certain matters—lodging-houses, offensive trades, cleansing streets, etc.

They must be confirmed by the Local Government Board, to give them authority.

Any ratepayer may inspect copy of By-Laws at the office of Local Authority at all reasonable times, free of charge. (See Local Government Board Model By-Laws.)

CELLAR DWELLINGS.

No cellar must be occupied unless—

1. Every part from floor to ceiling is 7 feet high, 3 feet being above the surface of the street.

2. Unless there is an area along the entire front, extending from 6 inches below the floor line to the level of the street, and 2 feet 6 inches wide in every part.

3. Unless well drained, the highest point of drain being at least one foot below the floor.

4. There must be a water-closet, earth-closet, or privy, and ash-pit.

5. There must be a chimney or flue, and an external window of at least nine superficial feet clear of the frame. An inner cellar, connected and used with the outer, must have a window of four superficial feet.

6. No steps or staircase must pass over in front of the window.

Alkali Acts, 1863, 1874.

The first Act enacts that 95 per cent. of the muriatic acid be condensed; the second provides that not more than half of a grain per cubic foot of muriatic acid be allowed to escape in any air, smoke, or chimney gases from the works. The term noxious gases shall mean "sulphuric acid, sulphurous acid, except that arising from the combustion of coals, nitric acid, or other noxious oxides of nitrogen, sulphuretted hydrogen and chlorine." An "alkali work" is every work for the manufacture of alkali, sulphate of soda, or potash, in which muriatic gas is evolved. The more recent Act adds the following:—"The formation of any sulphate in the treatment of copper ores by common salt or other chlorides, shall be deemed to be a manufacture of sulphate of soda."

Bakehouse Act, 1863.

No person under the age of eighteen may be employed in a bakehouse between 9 P.M. and 5 A.M.

The Act states that no place on a level with the bakehouse in any town over 5000 inhabitants, and forming part of the same building, shall be used as a sleeping-place, unless it is effectually separated from the bakehouse by a partition extending from floor to ceiling, and has an external glazed window of nine superficial feet, four and a half feet being made to open. All bakehouses must be kept clean, well ventilated, and lime-washed, and free from any smell from drain or privy.

THE POWERS AND DUTIES OF LOCAL AUTHORITY WITH REGARD TO SCAVENGING AND CLEANSING STREETS AND HOUSES.

Powers.—To provide for the scavenging and cleansing of streets; to provide receptacles for deposit of rubbish; to order removal of manure, or sell the same to pay expenses of removal.

Duties.—To cleanse streets when ordered by Local Government Board; to see that all houses are properly cleansed by order of Medical Officer; to see that pigs are not kept so as to be a nuisance; to prevent stagnant water or sewage from a cesspool becoming a nuisance or injurious to health; to provide for the cleansing of ditches, etc.

Note.—The Local Authority is subject to penalty after notice from occupiers for not removing refuse if they have contracted to do so.

THE POWERS AND DUTIES OF LOCAL AUTHORITY WITH REGARD TO CELLAR DWELLINGS AND LODGING-HOUSES.

Powers.—To close cellars in cases of two convictions; to refuse, if necessary, to register common lodging-houses; to make by-laws with regard to the same; to require water to be supplied to them; to order reports from keepers of houses taking vagrants; to make by-laws as to houses let in lodgings, if required to do so by Local Government Board.

Duties.—To keep register of the names and residences of all keepers of lodging-houses; to cause notice of registration to be fixed to all lodging-houses; to see that all lodging-houses are periodically lime-washed.

Note.—All keepers of common lodging-houses must now give *immediate* notice to Local Authority of any infectious disease occurring in their houses.

ANALYSTS.

These are appointed under the Foods and Drugs Act by the following bodies—

In England :—(*a*) The Commissioners of Sewers of the City of London and liberties thereof ; (*b*) Vestries and District Boards for other parts of the Metropolis ; (*c*) The Court of Quarter Sessions of every County ; (*d*) The Town Council of every Borough having a separate Court of Quarter Sessions, or having, under any general or local Act of Parliament or otherwise, a separate Police establishment.

In Scotland :—(*a*) The Commissioners of Supply ; (*b*) The Commissioners or Board of Police ; (*c*) The Town Councils of Boroughs.

The approving Authority, in the place of the Local Government Board in England, is one of Her Majesty's Principal Secretaries of State. They were first to be appointed immediately after the passing of the Act, and vacancies to be filled up as they occurred, or when required to be done, by Local Government Board.

Any persons possessing competent knowledge, skill, and experience as analysts of all articles of food and drugs sold within the district, might be appointed, but proof of competency must be supplied. The remuneration is left to the agreement of the parties. No person connected directly or indirectly in any trade or business for the sale of food or drugs in the district can be appointed analyst.

RIVERS POLLUTION PREVENTION ACT.

The object of this Act is to improve and preserve the purity and flow of rivers and streams of Great Britain. It is applicable to all rivers, streams, canals, lakes, and

water-courses, with the exception of water-courses at the passing of the Act mainly used as sewers, and emptying directly into the sea, or into tidal waters not declared to be streams within the Act. The four sources of pollution are—

(*a*) Solid refuse of manufactories, manufacturing processes, or quarries, rubbish and cinders, and any other waste or putrid matter; (*b*) Sewage matter, whether solid or liquid; (*c*) Poisonous, noxious, or polluting liquids proceeding from factories and manufacturing processes; (*d*) Solid or liquid matter from mines, which is poisonous, noxious, or polluting, or interferes with the flow of the water. "Solid matter" shall not include particles of matter in suspension in water. "Polluting" shall not include innocuous discolouration.

Proceedings may be taken in England against the person causing the pollution in the County Court of the district, or into a higher Court with the permission of the Judge of such Court. Local Authority must take proceedings against offenders, having first obtained the permission of the Local Government Board. If the Local Authority neglect to act, any individual aggrieved may appeal to the Local Government Board, who may or may not direct the Local Authority to begin an action. Due regard will be paid to the industrial interest involved in the case, and to the circumstances and requirements of the locality. This Act applies to Scotland and Ireland.

REGULATION OF DAIRIES, COWSHEDS, AND MILK-SHOPS.

The regulation of dairies, etc., is now, by the Contagious Diseases (Animals) Act, 1886, transferred from the Privy Council to the Local Government Board and Local Sanitary Authorities. Every Local Authority must now keep a Register of persons in their district,

carrying on the trade of cow-keepers, dairymen, or purveyors of milk, and renders it unlawful for any person to carry on such trade unless so registered. It further authorises Local Authorities to make Regulations :—

1. For the inspection of cattle in dairies.

2. For prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies and cowsheds in the occupation of persons following the trade of cow-keepers or dairymen.

> NOTE.—*The air space for cows should be from 800 to 1300 cubic feet for each cow. The Metropolitan regulations fix a minimum of 600 cubic feet in some cases and 800 in others.*

3. For securing the cleanliness of milk-stores, milk-shops, and of milk-vessels used for containing milk for sale by such persons.

4. For prescribing precautions to be taken by purveyors of milk, and persons selling milk by retail, against infection or contamination.

> NOTE.—*Registration is not one of the subjects about which Local Authorities can make regulations, for every cow-keeper, dairyman, etc., must register himself with the Local Authority, who cannot refuse, as this registration is one of persons not of premises.* The Local Authority have no power to make regulations prescribing conditions to be fulfilled before registration, as defect of premises must be dealt with separately as branches of the regulations. Persons who only make and sell butter and cheese, or who sell milk of their own cows in small quantities to their workmen or neighbours for their accommodation, are exempt from registration, but farmers sending milk by train to purveyors outside their district must be registered. The powers of entry are the same as under section 102 of the "Public Health Act, 1875." The Act applies to Scotland and Ireland.

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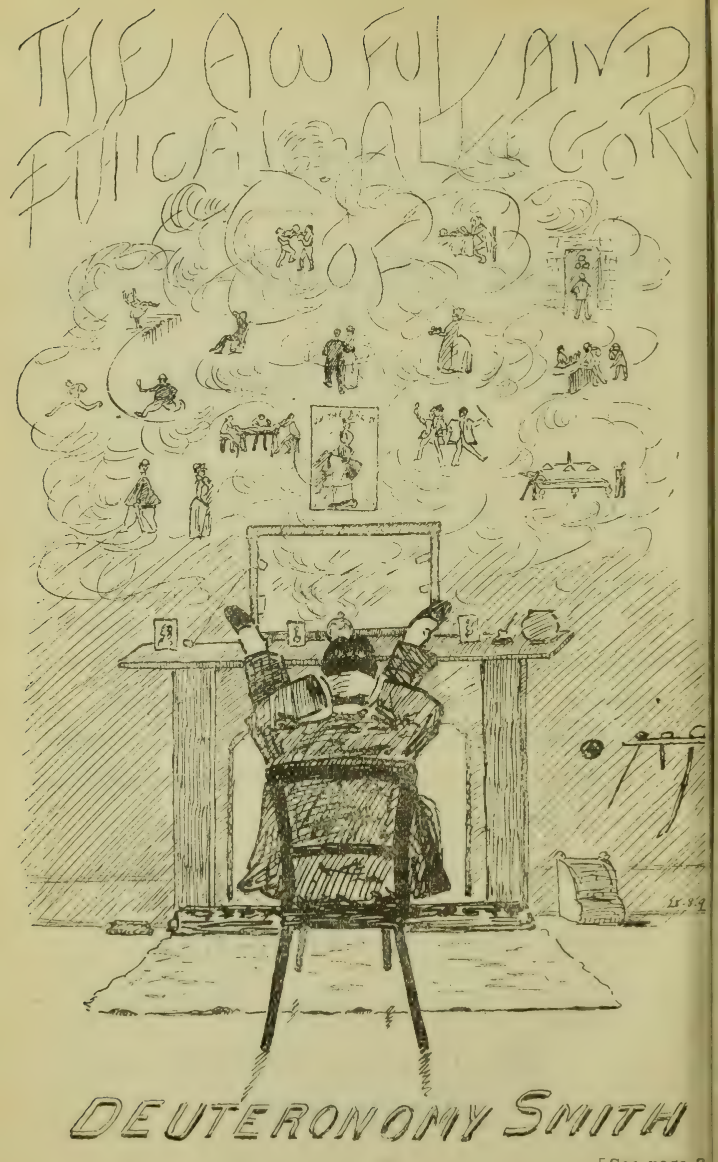

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